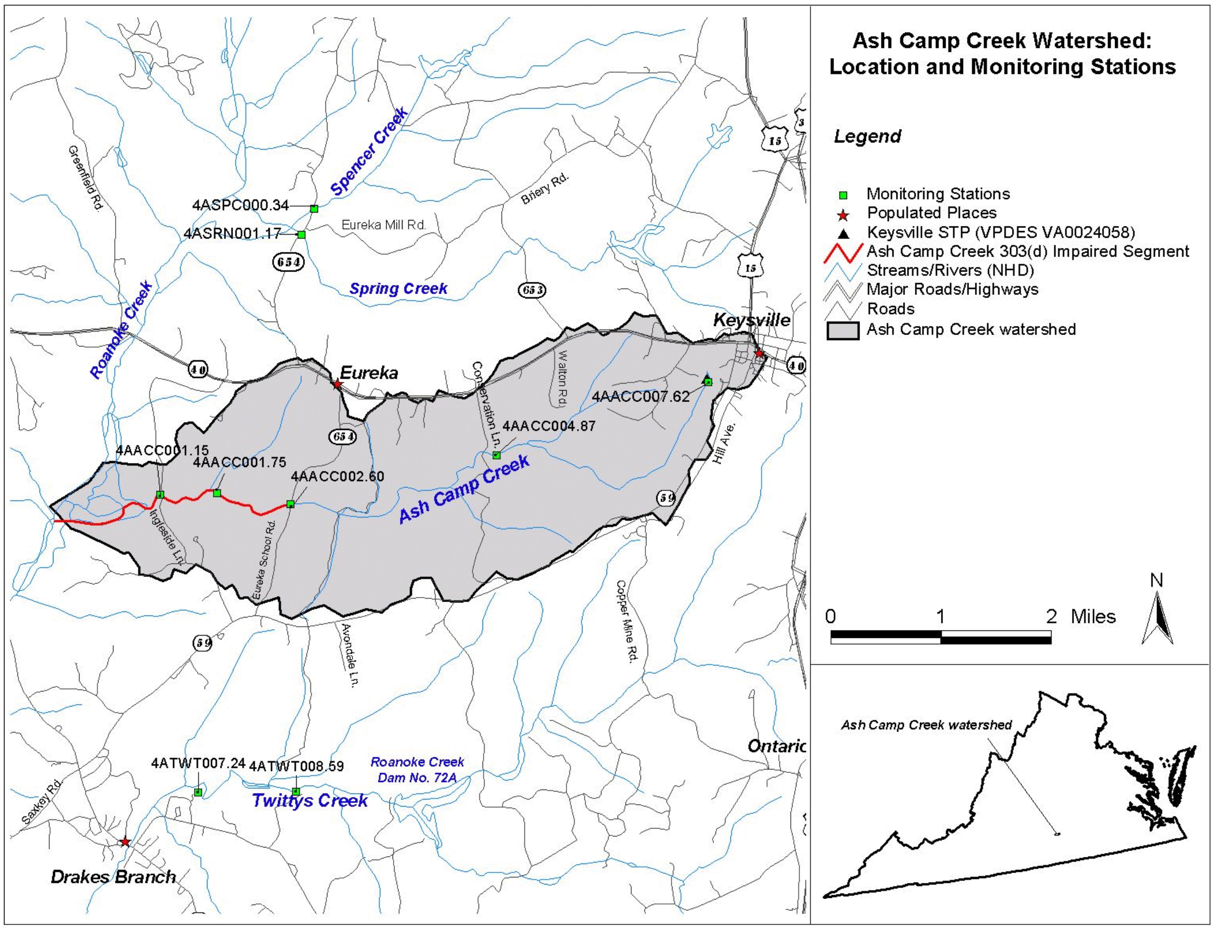
Total Maximum Daily Load (TMDL) Development for Ash Camp Creek

Aquatic Life Use (Benthic) Impairment



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Background

The Ash Camp Creek watershed is located in Charlotte County, Virginia, in the Roanoke River Basin (USGS Hydrologic Unit Code, 03010102) (Figure 1.1). The watershed is located approximately 4 miles west of Keysville, Virginia. The waterbody identification code (WBID, Virginia Hydrologic Unit) is VAC-L39R.

Virginia 305(b)/303(d) guidance states that support of the aquatic life beneficial use is determined by the assessment of conventional pollutants (dissolved oxygen, pH, and temperature); toxic pollutants in the water column, fish tissue and sediments; and biological evaluation of benthic community data (VADEQ 1997). Benthic community assessments are, therefore, used to determine compliance with the General Criteria section of Virginia's Water Quality Standards (9 VAC 25-260-20). In general, the stream reach that a biomonitoring station represents is classified as impaired if the EPA's Rapid Bioassessment Protocol (RBP) ranking is either moderately or severely impaired. As a result, Ash Camp Creek was listed as impaired due to violations of the general standard (aquatic life).

Water quality data analyses and field observations indicate that the primary causes of the benthic community impairment in Ash Camp Creek are excessive sedimentation and Keysville STP discharge problems. In order to improve water quality conditions that have resulted in benthic community impairments, Total Maximum Daily Loads (TMDLs) were developed for the impaired stream, taking into account all sources of sediment in the watersheds, plus a margin of safety (MOS). The Keysville STP is currently contributing elevated concentrations of TSS, ammonia, and copper to the stream; however, it is assumed that these pollutants will not be an issue once the facility upgrades are completed over the next few years.

Upon implementation, the TMDLs will ensure that water quality conditions relating to benthic impairment will meet the allowable loadings estimated by use of a reference watershed (a non-impaired watershed with characteristics similar to those of the impaired watersheds).

Sources of Sediment

Sediment sources can be divided into point and nonpoint sources. The Keysville STP (VA0024058) is the only point source located in the Ash Camp Creek watershed. This facility discharges to Ash Camp Creek just upstream of the DEQ biomonitoring station 4AACC007.62 (Table 1).

Table 1. Sediment point sources in the Ash Camp Creek watershed

Stream	Facility Name	VPDES Permit No.	Discharge Type	Design Flow (MGD)	Permitted Concentration (mg/L)	TSS Load (tons/year)
Ash Camp Creek	Keysville, STP	VA0024058	Municipal	0.500	30	20.7

Sediment loads are primarily contributed by nonpoint sources in the Ash Camp Creek watershed. The major source of sediment is agricultural land. Agricultural lands can contribute excessive sediment loads through erosion and build-up/washoff processes. Agricultural lands are particularly susceptible to erosion due to less vegetative coverage.

Modeling

TMDLs were developed using BasinSim 1.0 and the GWLF model. GWLF is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on daily water balance totals that are summed to give monthly values. In order to consider the spatial distribution of sources in the TMDL development, the Ash Camp Creek watershed was divided into six subbasins. Using a stream routing and transport module developed by Tetra Tech, the flow and pollutant loadings from each subwatershed are routed through the stream networks. The transport module also has the capability of assessing streambank erosion. The GWLF simulation results, including flow and sediment load, for each subwatershed are used to drive the stream flow routing, sediment transport, as well as streambank erosion simulation.

Daily streamflow data are needed to calibrate watershed hydrologic parameters in the GWLF model. The USGS streamflow gage (02051000), located on the North Meherrin River, was used in a paired watershed approach to calibrate hydrology for both the reference watershed (Twitty's Creek) and the impaired watershed (Ash Camp Creek). Flow data were available from this gage for the time period: January 1, 1991 - July 31, 1998. The calibration period covered a range of hydrologic conditions, including low- and high-flow conditions as well as seasonal variations. The calibrated GWLF model adequately simulated the hydrology of the impaired watershed.

TMDL development requires the identification of impairment causes and the establishment of numeric endpoints that will allow for the attainment of designated uses and water quality criteria. Numeric endpoints represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. Virginia does not currently have numeric criteria for sediment. Therefore, a reference watershed approach was used to determine the primary benthic community stressors and to establish a numeric endpoint for sediment. This approach is based on selecting a non-impaired watershed that shares similar land use, ecoregion, and geomorphological characteristics with the impaired watershed. Stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired stream to attain its designated uses. Twittys Creek was chosen as the reference watershed and any reductions of sediment from the impaired waterbodies was based on the reference loads of sediment in the Twittys Creek watershed.

Existing Conditions

Impaired and reference watershed models were calibrated for hydrology using different modeling periods and weather input files. To establish baseline (reference watershed) loadings for sediment the GWLF model for Twittys Creek was used. For TMDL calculation both the calibrated reference and impaired watershed were run for a 11-year period from 4/1/1991 to 3/31/2002. This was done to standardize the modeling period. In addition, the total area for the reference watershed was reduced to be equal to its paired target watershed. This was necessary because watershed size influences sediment delivery to the stream and other model variables.

The 11-year (April 1991 - March 2002) mean for sediment was determined for each land use/source category in these watersheds. This modeling period was used, after calibration, to represent a broad range of recent weather and hydrologic conditions.

Margin of Safety

While developing allocation scenarios for the TMDL, an explicit margin of safety (MOS) of ten percent was used. Ten percent of the reference sediment load was calculated and added to the sum of the load allocation (LA) and wasteload allocation (WLA) to produce the TMDL. It is assumed that a MOS of 10% will account for any uncertainty in the data and the computational methodology used for the analysis, as well as provide an additional level of protection for designated uses.

Allocation Scenarios

The recommended scenario for Ash Camp Creek (Table 2) is based on maintaining the existing percent load contribution from each source category. Table 2 presents the estimated results for the Ash Camp Creek watershed. The recommended scenarios balance the reductions from agricultural and urban sources by maintaining existing watershed loading characteristics. Permit requirements are expected to result in attainment of the WLAs as required by the TMDL; therefore, point source loads were not reduced.

Table 2. Recommended sediment allocations for Ash Camp Creek

Source Category	*Existing Loads*		*Allocated Loads (TMDL minus 10 % MOS)*		
	Sediment Load (ton/yr) *	Sediment % of Total	Sediment Load Allocation (ton/yr) *	Sediment % of Total	Sediment % Reduction
Pasture/Hay	261.0	44.0%	120.5	46.3%	53.8%
Row Crop	195.3	32.9%	72.5	27.8%	62.9%
Transitional	111.5	18.8%	41.8	16.1%	62.5%
Deciduous Forest	2.5	0.4%	2.5	0.9%	0.0%
Evergreen Forest	1.0	0.2%	1.0	0.4%	0.0%
Mixed Forest	1.4	0.2%	1.4	0.5%	0.0%
Urban	0.0	0.0%	0.0	0.0%	0.0%
Groundwater	0.0	0.0%	0.0	0.0%	0.0%
PointSource	20.7	3.5%	20.7	8.0%	0.0%
Total	**593.4**		**260.3**		**56.1%**

* Overall loads for sources were calculated by summing the loads from each source category in each subbasin.

The TMDLs established for these streams consist of a point source wasteload allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). The sediment TMDLs were based on the total load calculated for the Twittys Creek watershed (area adjusted to the appropriate watershed size).

The TMDL equation is as follows:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis.

TMDLs were calculated by adding reference watershed loads for sediment together with point source loads to give the TMDL value (Table 3).

Table 3. Sediment TMDL for Ash Camp Creek

Stream	Pollutant	TMDL (tons/yr)	LA (tons/yr)	WLA (tons/yr)	MOS (10%) (tons/yr)	Overall % Reduction
Ash Camp Creek	Sediment	289.2	239.6	20.7 (*Keysville STP = 20.7*)	28.9	56.1%

SECTION 1

INTRODUCTION

1.1 Background

1.1.1 TMDL Definition and Regulatory Information

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (USEPA 1991).

1.1.2 Impairment Listing

Ash Camp Creek is listed as impaired on Virginia's Section 303(d) Total Maximum Daily Load Priority List and Report due to violations of the General Standard (Benthics) (VADEQ 1998 & 2002). Ash Camp Creek was placed on Virginia's Section 303(d) list in 1998 for partial support of the Aquatic Life Use based on comparisons to the reference stream, Twittys Creek. The impaired segment is 2.36 miles and extends from the Route 654 Bridge to its confluence with Roanoke Creek.

1.1.3 Watershed Location

The Ash Camp Creek watershed is located in Charlotte County, Virginia, in the Roanoke River Basin (USGS Hydrologic Unit Code, 03010102) (Figure 1.1). The waterbody identification code (WBID, Virginia Hydrologic Unit) is VAC-L39R.

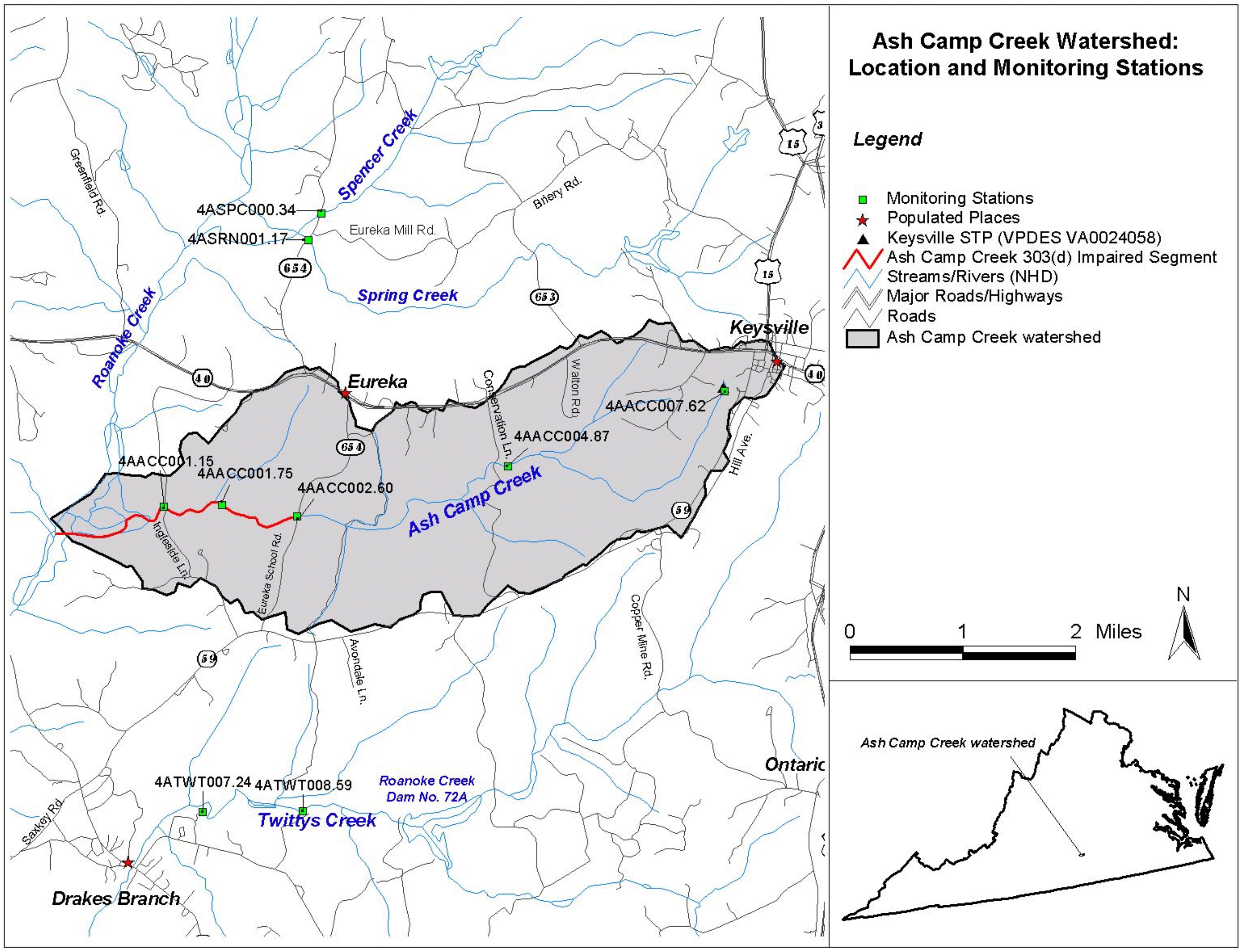

Figure 1.1 Location of TMDL watershed

1.2 Designated Uses and Applicable Water Quality Standards

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "Water quality standards" *means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§ 62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC § 1251 et seq.).*

1.2.1 Designation of Uses (9 VAC 25-260-10)

A. All state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might reasonable be expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish).

Ash Camp Creek does not support the aquatic life designated use due to violations of the general (benthic) criteria (see Section 1.2.2).

1.2.2 Water Quality Standards

General Criteria (9 VAC 25-260-20)
A. All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.

Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled.

1.3 Biomonitoring and Assessment

Direct investigations of biological communities using rapid bioassessment protocols, or other biosurvey techniques, are best used for detecting aquatic life impairments and assessing their relative severity (Plafkin et al. 1989). Biological communities reflect overall ecological integrity; therefore, biosurvey results directly assess the status of a waterbody relative to the primary goal of the Clean Water Act. Biological communities integrate the effects of different pollutant stressors and thus provide a holistic measure of their aggregate impact. Communities also integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions.

Many state water quality agencies use benthic macroinvertebrate community data to assess the biological condition of a waterbody. Virginia uses EPA's Rapid Bioassessment Protocol (RBP II) to determine the status of a stream's benthic macroinvertebrate community. This procedure relies on comparisons of the benthic macroinvertebrate community between a monitoring station and its designated reference site. Measurements of the benthic community, called metrics, are used to identify differences between monitored and reference stations. Metrics used in the RBP II protocol include taxa richness, percent contribution of dominant family, and other measurements that provide information on the abundance of pollution tolerant versus pollution intolerant organisms. Biomonitoring stations are typically sampled in the spring and fall of each year. The biological condition scoring criteria and the bioassessment matrix are discussed in the technical document, *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish* (Plafkin et al. 1989). The RBPII bioassessment scoring matrix is presented in Table 1.1.

Table 1.1 Bioassessment scoring matrix (Plafkin et al. 1989)

% Compare to Reference Score (a)	Biological Condition Category	Attributes
>83%	Non-Impaired	Optimum community structure (composition and dominance).
54 - 79%	Slightly Impaired	Lower species richness due to loss of some intolerant forms.
21 - 50%	Moderately Impaired	Fewer species due to loss of most intolerant forms.
<17%	Severely Impaired	Few species present. Dominant by one or two taxa. Only tolerant organisms present.
(a) Percentage values obtained that are intermediate to the above ranges require subjective judgement as to the correct placement.		

Virginia 305(b)/303(d) guidance states that support of the aquatic life beneficial use is determined by the assessment of conventional pollutants (dissolved oxygen, pH, and temperature); toxic pollutants in the water column, fish tissue and sediments; and biological evaluation of benthic community data (VADEQ 1997). Benthic community assessments are, therefore, used to determine compliance with the General Criteria section of Virginia's Water Quality Standards (9 VAC 25-260-20). In general, the stream reach that a biomonitoring station represents is classified as impaired if the RBP ranking is either moderately or severely impaired. As a result, Ash Camp Creek was listed as impaired due to violations of the general standard (aquatic life).

SECTION 2

BENTHIC TMDL ENDPOINT DETERMINATION

2.1 Reference Watershed Approach

Biological communities respond to any number of environmental stressors, including physical impacts and changes in water and sediment chemistry. According to Virginia's 2002 303(d) list, the probable cause of benthic impairment was attributed to siltation from the Keysville STP.

TMDL development requires the identification of impairment causes and the establishment of numeric endpoints that will allow for the attainment of designated uses and water quality criteria. Numeric endpoints represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. Virginia does not currently have numeric criteria for nutrients (i.e. total phosphorus and total nitrogen), sediment, and other parameters that may be contributing to the impaired condition of the benthic community in this stream. A reference watershed approach was, therefore, used to determine the primary benthic community stressors and to establish numeric endpoints for these stressors. This approach is based on selecting non-impaired watersheds that share similar land use, ecoregion, and geomorphological characteristics with the impaired watershed. Stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired stream to attain its designated uses. The Virginia Stream Condition Index (VaSCI) was used to define differences in the benthic communities in impaired and reference streams (USEPA, 2003a). Loading rates for pollutants of concern are determined for impaired and reference watersheds through modeling studies. Both point and nonpoint sources are considered in the analysis of pollutant sources and in watershed modeling. Numeric endpoints are based on reference watershed loadings for pollutants of concern and load reductions necessary to meet these endpoints are determined. TMDL load allocation scenarios are then developed based on an analysis of the degree to which contributing sources can be reasonably reduced

2.2 Watershed Characterization

2.2.1 General Information

The Ash Camp Creek watershed is located in Charlotte County, Virginia, in the Roanoke River Basin (USGS Hydrologic Unit Code, 03010102) (Figure 1.1). The watershed is located approximately 4 miles west of Keysville, Virginia. The waterbody identification code (WBID, Virginia Hydrologic Unit) is VAC-L39R. The impaired stream length is approximately 2.36 miles and extends from the Route 654 Bridge to its confluence with Roanoke Creek. The Ash Camp Creek watershed is approximately 6,155 acres.

2.2.2 Geology

Ash Camp Creek is located in the Piedmont physiographic province. The Piedmont physiographic province is the largest physiographic province in Virginia. It is bounded on the east by the Fall Zone, which separates the province from the Coastal Plain, and on the west by the mountains of the Blue Ridge province. The province is characterized by gently rolling topography and deeply weathered bedrock. Rocks are strongly weathered in the Piedmont's humid climate and bedrock is generally buried under a thick (2-20 m) blanket of saprolite Outcrops are commonly restricted to stream valleys where saprolite has been removed by erosion. The predominant rocks found in the region are gneiss, schist, and granite, of which quartz, feldspar, and mica are the primary minerals. Igneous and metamorphic rocks with a high base content of calcium and magnesium are also found in lesser quantities.

2.2.3 Soils

Soils data were obtained from the State Soil Geographic (STATSGO) database which includes general soils data and map unit delineations for the United States. GIS coverages provide accurate locations for the soil map units (MUIDs) at a scale of 1:250,000 (USDA, 1995). A map unit is composed of several soil series having similar properties. STATSGO map units that cover a portion of the Ash Camp Creek watershed are shown in Figure 2.1. The following soil series descriptions are based on NRCS Official Soil Descriptions (1998-2002).

STATSGO Soil Type VA019 is composed of the Cecil series, the Madison series, the Enon series, the Wilkes series, and the Chewacla series. The Cecil series accounts for 78% of the map unit. The Cecil series consists of very deep, well drained soils formed in residuum weathered from felsic, igneous and high-grade metamorphic rocks of the Piedmont uplands. The series is located on ridges and side slopes of the Piedmont uplands. Permeability is moderate, with slopes range from 0% to 25%. Hydrologic soil group - B.

STATSGO Soil Type VA042 is composed of the Mayodan series, the Creedmor series, the Pinkston series and the Partlow series. The Mayodan series accounts for 50% of the map unit. The Mayodan series is composed of very deep, well drained, moderately permeable soils, with slopes ranging from 1% to 50% percent.. The soils were formed in residuum weathered from Triassic materials of the Piedmont uplands. Hydrologic soil group - B.

STATSGO Soil Type VA045 is composed of the Georgeville series, the Nason series, the Lignum series, the Iredell series, the Goldston series and the Orange series. The Georgeville series accounts for 80% of the map unit. The Georgeville series consists of very deep, very well drained, moderately permeable soils, with slopes ranging from 2% to 50%. The soils were formed in material weathered from fine-grained metavolcanic rocks of the Carolina Slate Belt. Hydrologic soil group - B.

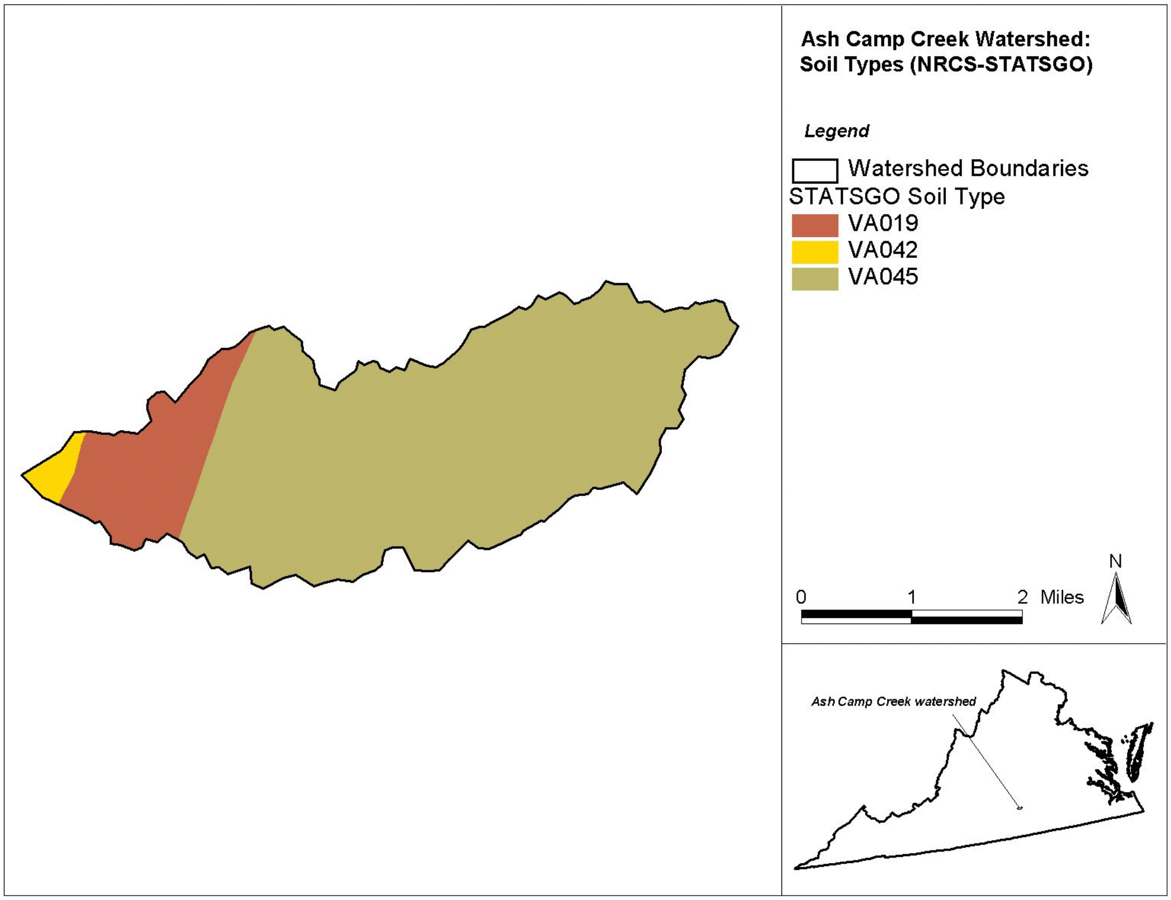

Figure 2.1 STATSGO soil types for the Ash Camp Creek watershed

2.2.4 Climate

The area's climate is typical of other Piedmont areas in Virginia. Weather data for these watersheds can be characterized using the Camp Pickett meteorological station (NCDC), which is located approximately 30 miles to the east of the watershed (period of record: 1972-2003). The growing season lasts from April 22 through October 16 in a typical year (SERCC 2003). Average annual precipitation is 46 inches with March having the highest average precipitation (4.52 inches). Average annual snowfall is 7.8 inches, most of which occurs in January and February. The average annual maximum and minimum daily temperature is 68.9ºF and 43.8ºF, respectively. The highest monthly temperatures are recorded in July (88.2ºF - avg. maximum) and the lowest temperatures are recorded in January (24.0ºF - avg. minimum).

2.2.5 Land Use

General land use/land cover data for the Ash Camp Creek watershed was extracted from the Multi-Resolution Land Characterization (MRLC) database for the state of Virginia (MRLC, 1992) and is shown in Figure 2.2. This database was derived from satellite imagery taken during the early 1990s and is the most current detailed land use data available. Land uses in the watershed include various urban, agricultural, and forest categories (Table 2.1 and Figure 2.2). Approximately 74% of the watershed is forested, while 14% of the watershed is used for agricultural purposes. Open water and wetlands account for almost 7% of the watershed, while residential and commercial development account for only about 5% of the watershed.

Table 2.1 MRLC land use in the Ash Camp Creek watershed

Land Use Type	Acres	%
Open Water	8	0.14%
Low Intensity Residential	67	0.99%
High Intensity Residential	3	0.04%
Commercial/Industrial/Transportation	11	0.15%
Transitional	233	3.90%
Deciduous Forest	2460	39.79%
Evergreen Forest	837	13.47%
Mixed Forest	1312	21.10%
Pasture/Hay	826	13.17%
Row Crops	58	0.89%
Woody Wetlands	293	5.94%
Emergent Wetlands	26	0.43%

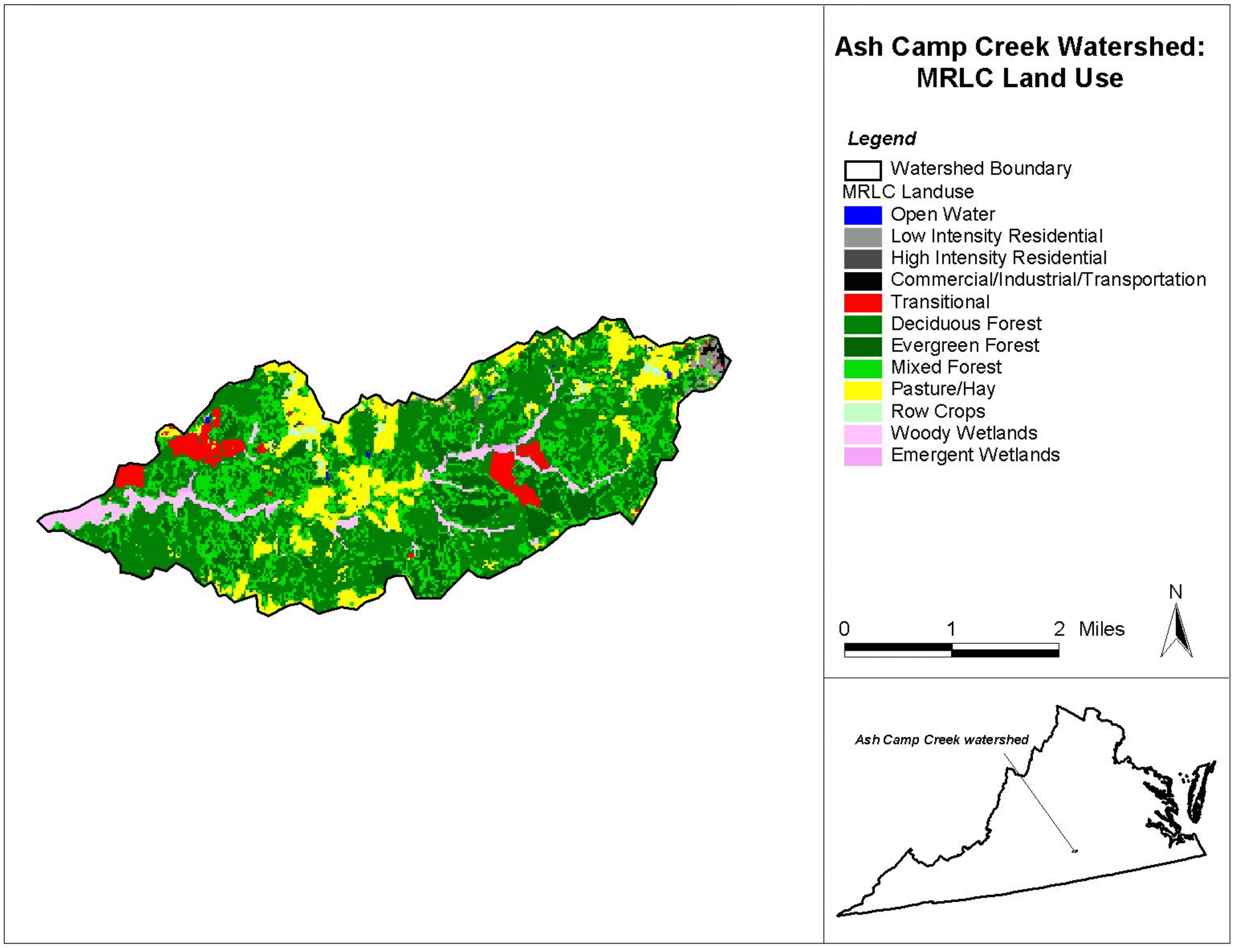

Figure 2.2 MRLC land use in the Ash Camp Creek watershed

2.2.6 Ecoregion

The Ash Camp Creek watershed is located in the Piedmont ecoregion - Level III classification 45 (Woods et al. 1999) (Figure 2.3). This ecoregion extends from Wayne County, Pennsylvania, southwest through Virginia. It is characterized by irregular plains, low rounded hills and ridges, shallow valley and scattered monadnocks. It is mostly forested and is a transition zone between the mountainous ecoregions to the west and the flatter coastal ecoregions to the east. The Piedmont is underlain with deeply weathered, deformed metamorphic rocks with intrusions by igneous material. The humid, warm temperate climate originally supported Oak-Hickory-Pine forests with much of the forest lost to agriculture, causing significant soil loss. Today many abandoned field are reverting to forest. Stream gradients are typically low to moderate with the moderate gradient streams concentrated in the hillier areas. Falls, islands and rapids and associated fish assemblages are found along the eastern border of the Piedmont in the Fall Zone.

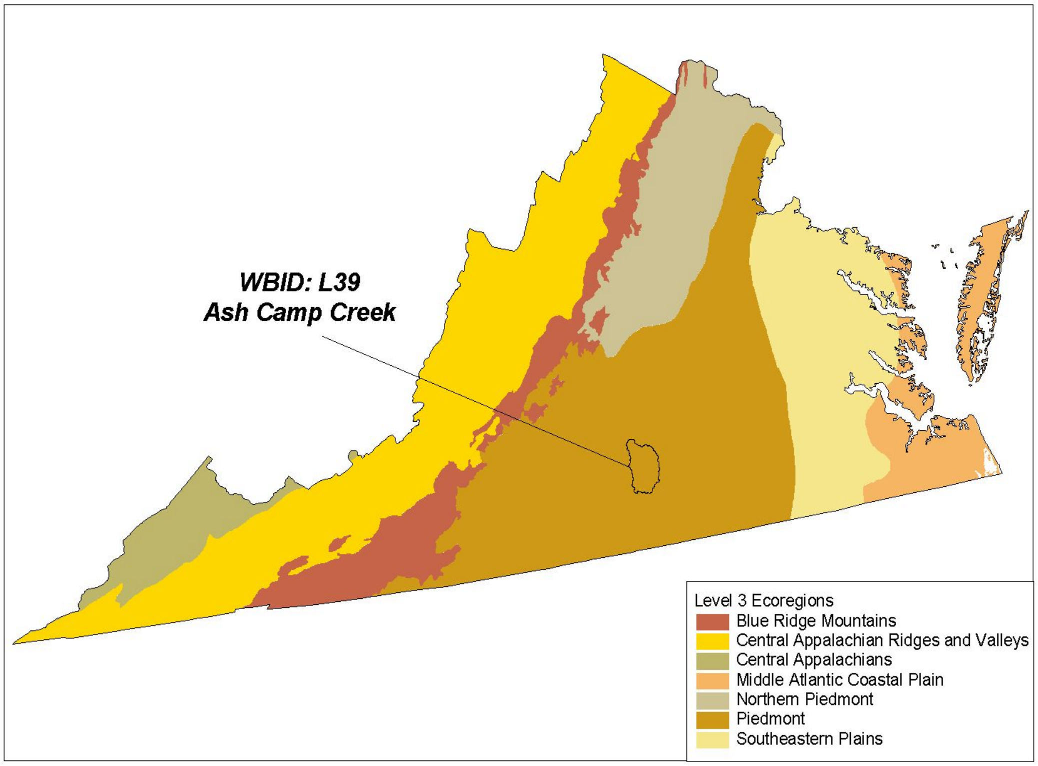

Figure 2.3 Virginia Level III ecoregions

At a finer scale, the Ash Camp Creek watershed is located in the Carolina Slate Belt and Northern Outer Piedmont subecoregion - Level IV classifications, 45c and 45f (Woods et al. 1999) (Figure 2.4). The Carolina Slate Belt subecoregion is characterized by low rounded ridges and shallow ravines over an irregular plain. It is underlain by deeply weathered, fine-grained metavolcanic and metasedimentary rocks with intrusions of igneous rocks. The subecoregion is underlain by aaron slate, phyllite, metasiltstone, metatuff, felsic volcanic rocks and Virgilina Greenstone, which tend to be less resistant to erosion than those in adjoining subecoregions. The soils of the Carolina Slate Belt were derived from residuum and have a high silt content. This subecoregion tends to have lower crestal elevations and wider valleys resulting in more favorable sites for reservoirs. Local relief ranges from 50 to 250 feet.

The Northern Outer Piedmont subecoregion is characterized by low rounded ridges and shallow ravines on an irregular plain. The subecoregion is underlain by deformed, deeply weathered gneissic rock with intrusions by plutons and is veneered with saprolite. Stream flow velocities tend to be moderately slow with both riffles and runs short and infrequent. Stream substrates are composed mainly of sand, silt, clay and detritus. The vegetation is classified as Oak-Hickory-Pine Forest with hickory, shortleaf pine, loblolly pine, white oak and post oak dominating. Local relief varies from 100 to 250 feet.

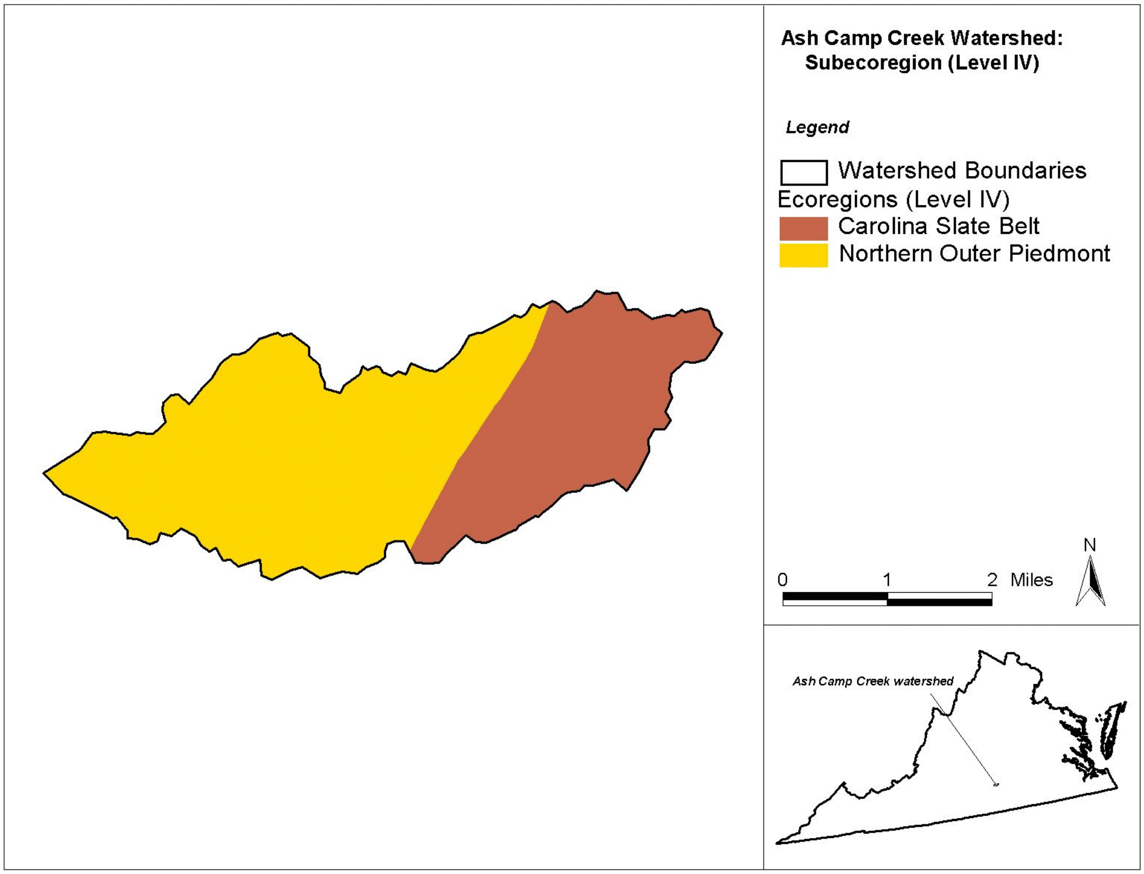

Figure 2.4 Level IV ecoregions in the Ash Camp Creek watershed

2.3 Reference Watershed Selection

The reference watershed selection process is based on a comparison of key watershed, stream and biological characteristics. The goal of the process is to select one or several similar, unimpaired reference watersheds that can be used to identify benthic community stressors and develop TMDL endpoints. Reference watershed selection was based on the results of VADEQ biomonitoring studies and comparisons of key watershed characteristics. Data used in the reference watershed selection process for Ash Camp Creek are shown in Table 2.2.

Table 2.2 Reference watershed selection data

Biomonitoring Data	Ecoregion Coverages
Topography	Land use Distribution
Soils	Watershed Size
Water Quality Data	Point Source Inventory

Tetra Tech, VADEQ, and USEPA recently developed the Virginia Stream Condition Index (VaSCI), which provides a more detailed and reliable assessment of the benthic macroinvertebrate community in Virginia's non-coastal, wadeable streams (USEPA, 2003a). This new multi-metric index, was used to compare relative differences in the benthic community between impaired and reference streams. This index allows for the evaluation of biological condition as a factor in the reference watershed selection process and can be used to measure improvements in the benthic macroinvertebrate community in the future. VADEQ biomonitoring data were used to calculate the VaSCI scores shown in Table 2.4. The Twittys Creek reference scores are shown for comparison.

Table 2.3 Bioassessment index comparison

Station ID	Stream	Sample Date	VaSCI Score
			Avg
Current TMDLs			
ACC001.60	Ash Camp Creek	11/29/94	45
		6/6/95	40
		4/16/96	48
		11/20/96	49
		6/2/97	45
		11/14/97	49
		15/5/02	40
		9/30/02	38
		Average	44
ACC004.87	Ash Camp Creek	6/21/02	54
		9/30/02	41
		Average	48
AC007.62	Ash Camp Creek	7/30/02	24
		9/30/02	10
		Average	17
TWT008.59	Twittys Creek	7/2/02	52
		10/3/02	50
		Average	51

2.4 Selected Reference Watershed

The Twittys Creek watershed, delineated at the VADEQ biomonitoring station, was selected as the reference for this TMDL study (Figure 2.5). This determination was based on the degree of similarity between this stream and its associated watershed to the impaired stream and the results of the VaSCI scores.

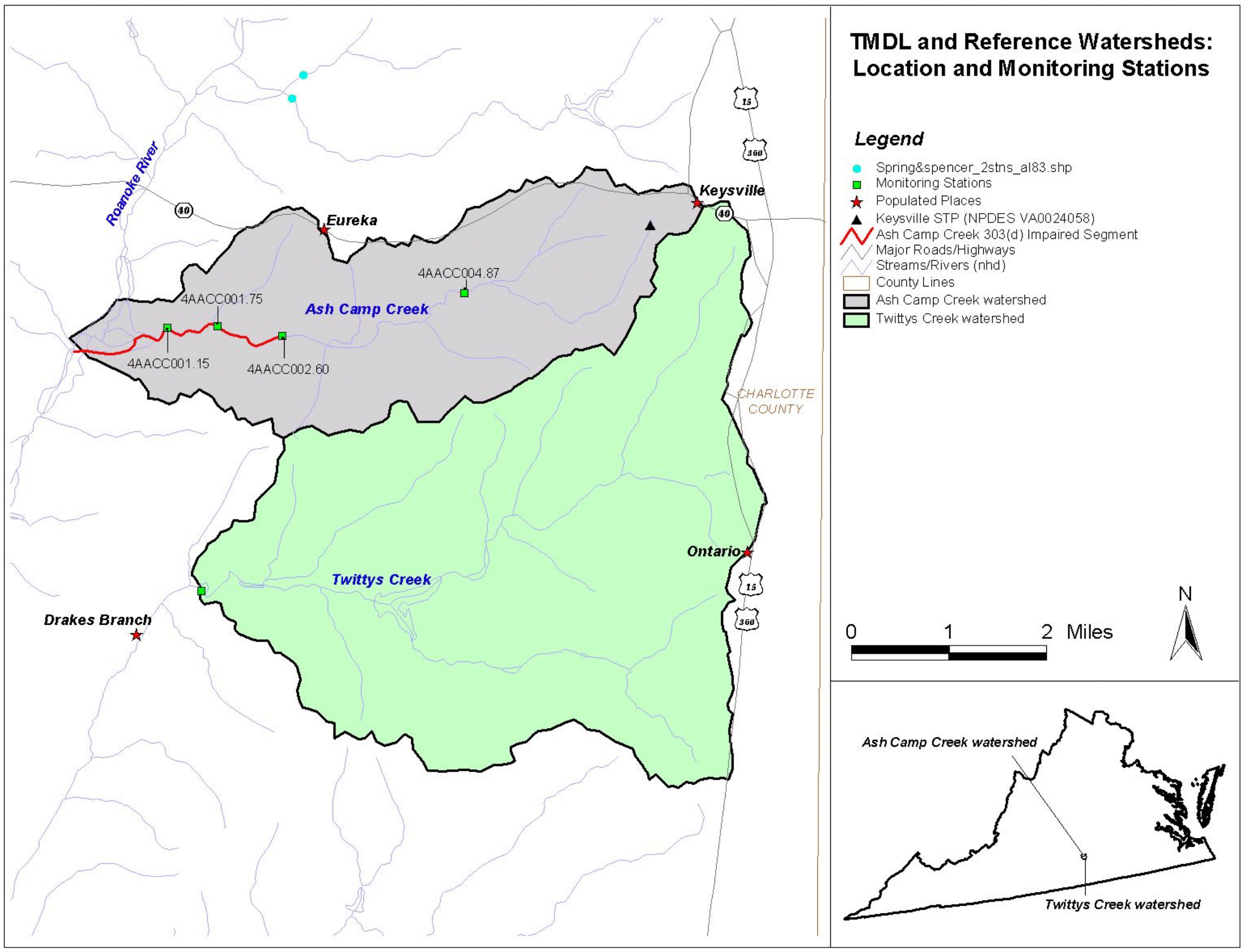

Figure 2.5 Twittys Creek watershed location and monitoring stations

SECTION 3

STRESSOR IDENTIFICATION

3.1 Stressor Identification Process

Biological assessments are useful in detecting impairment, but they do not necessarily identify the cause(s) of impairment. EPA developed the *Stressor Identification: Technical Guidance Document* to assist water resource managers in identifying stressors or combinations of stressors that cause biological impairment (Cormier et al. 2000). Elements of the stressor identification process were used to evaluate and identify the primary stressors of the benthic community in Ash Camp Creek. Watershed and water quality data from these streams, reference watershed data, and field observations were used to help identify candidate causes.

3.2 Candidate Causes

Based on information provided by VADEQ and watershed data collected at the beginning of the TMDL study, it was hypothesized that excessive sedimentation was responsible for the listed benthic impairments. A field visit to Ash Camp Creek was conducted by Tetra Tech and VADEQ personnel on April 1, 2003 to gather information on stream and watershed characteristics for stressor identification and modeling studies. Field observations confirmed the likelihood that sedimentation was primarily responsible for negative impacts to the benthic macroinvertebrate community in this stream. Potential stressors and their relationships to benthic community condition are discussed below.

3.2.1 Low Dissolved Oxygen

Organic enrichment can cause low dissolved oxygen (DO) levels which stress benthic organisms. In general, high nitrogen and phosphorus levels can lead to increased production of algae and macrophytes, which can result in the depletion of oxygen in the water column through metabolic respiration. In addition, at higher water temperatures the concentration of dissolved oxygen is lower because the solubility of oxygen (and other gases) decreases with increasing temperature. Higher water temperatures can be caused by the loss of shading, higher evaporation rates, reduced stream flow, and other factors.

Aquatic organisms, including benthic macroinvertebrates, are dependent upon an adequate concentration of dissolved oxygen. Less tolerant organisms generally cannot survive or are out-competed by more tolerant organisms under low dissolved oxygen conditions. This process reduces diversity and alters community composition from a natural state. Aquatic insects and other benthic organisms serve as food items for fishes, therefore, alterations in the benthic community can impact fish feeding ecology (Hayward and Margraf 1987; Leach et al. 1977).

3.2.2 Sedimentation

Excessive sedimentation from anthropogenic sources is a common problem that can impact the stream biota in a number of ways. Deposited sediments reduce habitat complexity by filling pools, critical riffle areas, and the interstitial spaces used by aquatic invertebrates. Substrate size is a particularly important factor that influences the abundance and distribution of aquatic insects. Sediment particles at high concentrations can directly affect aquatic invertebrates by clogging gill surfaces and lowering respiration capacity. Suspended sediment also increases turbidity in the water column which can affect the feeding efficiency of visual predators and filter feeders. In addition, pollutants, such as phosphorus, adsorb to sediment particles and are transported to streams through erosion processes.

3.2.3 Habitat Alteration

The lack of an adequate riparian buffer along sections of the stream was considered to be a potential factor affecting the benthic community. Minimal riparian vegetation was observed in specific areas during the TMDL field visit. Riparian areas perform many functions that are critical to the ecology of the streams that they border. Functional values include:

- Flood detention
- Nutrient cycling
- Plant roots stabilize banks and prevent erosion
- Wildlife habitat
- Canopy vegetation provides shading (decreases water temperature and increases baseflow through lower evaporation rates)

3.2.4 Toxic Pollutants

Toxic pollutants in the water column and sediment can result in acute and chronic effects on aquatic organisms. Increased mortality rates, reduced growth and fecundity, respiratory problems, tumors, deformities, and other consequences have been documented in toxicity studies of aquatic organisms. Degraded water quality conditions and other environmental stressors can lead to higher rates of incidence of these problems.

3.3 Monitoring Stations

There are five current and historical monitoring stations on Ash Camp Creek. As part of a special study, targeted monitoring was performed in December 2001 and January 2002 to help identify the causes of benthic impairment. This monitoring took place at three stations on Ash Camp Creek (4AACC001.15, 4AACC002.60, and 4AACC004.87). Station 4AACC001.75 is a probabilistic monitoring station and was sampled on only one occasion (May 8, 2002). Additional data were collected at station 4AACC002.60 between July 1968 and June 1979. There are three biomonitoring stations on Ash Camp Creek (4AACC002.60, 4AACC004.87, and 4AACC007.62). All of the monitoring stations located on Ash Camp Creek and Twittys Creek (reference stream) are listed in Table 3.1.

Table 3.1 Monitoring stations on Ash Camp Creek and Twittys Creek

Stream	Station	Location	AWQM: Data Period	Biomonitoring: Data Period
Ash Camp Creek	4AACC001.15	Upstream side of Ingleside Lane Bridge	12/17/01 - 1/28/02	N/A
	4AACC001.75	0.85 mile downstream of Route 654 bridge (probabilistic monitoring station)	5/8/02	N/A
	4AACC002.60	Upstream side of Route 654 Bridge	7/11/68 – 12/11/02	11/29/94 – 9/30/02
	4AACC004.87	Upstream of Conservation Road Bridge	9/20/01 – 12/11/02	6/21/02 – 9/30/02
	4AACC007.62	50 yards below Keysville STP discharge	N/A	7/3/02 – 9/30/02
Twittys Creek	4ATWT007.24	25 feet downstream of low head dam, upstream of West Point Stevens discharge	N/A	11/29/94 – 11/13/97
	4ATWT008.59	Below Town Lake at power line	N/A	7/2/02 – 10/3/02

Station 4AACC001.15 is the most downstream monitoring site and is represented by very slow-moving flow and wetland conditions. Station 4AACC001.75 is above station 4AACC001.15, but only has one day of sampling data (May 8, 2002). Station 4AACC002.60 is at Route 654 and is characterized by eroded banks with little riparian vegetation and moderate sediment loads. Station 4AACC004.87 is characterized by forest riparian buffers and low sediment loads. The most upstream station, 4AACC007.62, is located 50 yards downstream of the Keysville STP discharge which contributes the majority of the streamflow at this point during dry periods.

3.4 Water Quality and Sediment Data Summary

3.4.1 Monitoring Summary Tables

Ash Camp Creek is classified as a Coastal and Piedmont Zone non-tidal waterbody (Class III) in Virginia Water Quality Standards (9 VAC 25-260-50). Numeric criteria for dissolved oxygen (DO), pH, and maximum temperature for Class III waters are shown in Table 3.2.

Table 3.2 Virginia numeric criteria for Class III waters

Dissolved Oxygen (mg/L)			
Minimum	Daily Average	pH (standard units)	Maximum Temperature (ºC)
4.0	5.0	6.0 - 9.0	32

Water quality and sediment data were summarized to help determine general stream characteristics. Tables 3.3 through 3.8 present a summary of all monitored parameters. Water quality data collected during biomonitoring field visits are summarized separately for each station. Station 4AACC002.60 is the only station with monitoring data collected prior to the December 2001/January 2002 special study. Two summary tables are presented for this station: Table 3.5 presents summary statistics for the period of record and Table 3.6 summarizes the data collected since 2001. Water quality analyses were based on comparing the recent data (2001 to present) for all stations. The historical data collected at Station 4AACC002.60 gives additional information regarding past water quality conditions on Ash Camp Creek.

Table 3.3 Monitoring Summary for Ash Camp Creek - 4AACC001.15 (Period of Record: 12/17/2001-1/28/2002)

Parameter	Minimum	Maximum	Average	Median	Number of Observations
DISSOLVED OXYGEN (MG/L)	7.88	11.21	9.67	9.79	4
PH	6.97	7.59	7.17	7.06	4
BOD5 (MG/L)	2.00	2.00	2.00	2.00	4
TSS (MG/L)	3.00	6.00	4.25	4.00	4
TOTAL NITRITE (MG/L as N)	0.01	0.01	0.01	0.01	4
TOTAL NITRATE (MG/L as N)	0.08	0.42	0.18	0.12	4
TKN (MG/L as N)	0.20	0.30	0.28	0.30	4
TOTAL PHOSPHORUS (MG/L as P)	0.04	0.07	0.06	0.06	4
PHOSPHORUS, IN TOTAL ORTHOPHOSPHATE(MG/L as P)	0.04	0.04	0.04	0.04	4

Table 3.4 Monitoring Summary for Ash Camp Creek - 4AACC001.75 (Period of Record: 5/8/2002)

Parameter	Minimum	Maximum	Average	Median	Number of Observations
DISSOLVED OXYGEN (MG/L)	6.89	6.89	6.89	6.89	1
PH	7.09	7.09	7.09	7.09	1
TURBIDITY FTU - HACH TURBIDIMETER	7.3	7.3	7.3	7.3	1
LAB SPECIFIC CONDUCTANCE	148	148	148	148	1
PH, LAB (SU)	7.03	7.03	7.03	7.03	1
ALKALINITY (MG/L AS CA CO3)	51.5	51.5	51.5	51.5	1
TOTAL SOLIDS, (MG/L)	124	124	124	124	1
VOLATILE SOLIDS (MG/L)	20	20	20	20	1
FIXED SOLIDS (MG/L)	104	104	104	104	1
DISSOLVED SOLIDS, TOTAL (MG/L)	110	110	110	110	1
TOTAL SUSPENDED SOLIDS (MG/L)	4	4	4	4	1
VOLATILE SUSPENDED SOLIDS (MG/L)	3	3	3	3	1
FIXED SUSPENDED SOLIDS (MG/L)	3	3	3	3	1
AMMONIA, TOTAL (MG/L AS N)	0.21	0.21	0.21	0.21	1
NITRITE, TOTAL (MG/L AS N)	0.04	0.04	0.04	0.04	1
NITRATE, TOTAL (MG/L AS N)	0.24	0.24	0.24	0.24	1
NITROGEN, TOTAL KJELDAHL (MG/L AS N)	0.7	0.7	0.7	0.7	1
PHOSPHORUS, TOTAL (MG/L AS P)	0.1	0.1	0.1	0.1	1
ORGANIC CARBON, IN BED MATERIAL(GM/KG AS C)	5.7	5.7	5.7	5.7	1
HARDNESS, EDTA (MG/L AS CACO3)	50.7	50.7	50.7	50.7	1
CHLORIDE, TOTAL (MG/L)	7.14	7.14	7.14	7.14	1
SULFATE, TOTAL (MG/L AS SO4)	7.99	7.99	7.99	7.99	1
FLUORIDE, TOTAL (MG/L AS F)	0.13	0.13	0.13	0.13	1
ARSENIC, SEDIMENT (MG/KG DRY WT)	5	5	5	5	1
BERYLLIUM, SED (MG/KG AS BE DRY WT)	5	5	5	5	1
CADMIUM, SEDIMENT (MG/KG DRY WT)	1	1	1	1	1
CHROMIUM, SEDIMENT (MG/KG DRY WT)	15.9	15.9	15.9	15.9	1
COPPER, SEDIMENT (MG/KG AS CU DRY WT)	12.7	12.7	12.7	12.7	1
LEAD, SEDIMENT (MG/KG AS PB DRY WT)	5.05	5.05	5.05	5.05	1
MANGENESE, SEDIMENT (MG/KG AS DRY WT)	217	217	217	217	1
NICKEL, SEDIMENT (MG/KG DRY WT)	6.31	6.31	6.31	6.31	1
SILVER, SEDIMENT (MG/KG AS AG DRY WT)	1	1	1	1	1
ZINC, SEDIMENT (MG/KG AS ZN DRY WT)	28.8	28.8	28.8	28.8	1
ANTIMONY, SEDIMENT (MG/KG AS	5	5	5	5	1

Parameter	Minimum	Maximum	Average	Median	Number of Observations
SB DRY WT)					
ALUMINUM, SEDIMENT (MG/KG AS AL DRY WT)	6400	6400	6400	6400	1
SELENIUM, SEDIMENT (MG/KG AS SE DRY WT)	1	1	1	1	1
IRON, SEDIMENT (MG/KG AS DRY WT)	11900	11900	11900	11900	1
FECAL COLIFORM (MFM-FCBR/100 ML) MFM	2000	2000	2000	2000	1
E. COLI – MTEC-MF NO./100 ML	800	800	800	800	1
ENTEROCOCCI COLONIES/100 ML	520	520	520	520	1
CHLOROPHYLL A, UNCORRECTED (UG/L)	1.53	1.53	1.53	1.53	1
CHLOROPHYLL A, CORRECTED (UG/L)	0.98	0.98	0.98	0.98	1
CHLOROPHYLL B (TRICHROMATIC)	0.5	0.5	0.5	0.5	1
CHLOROPHYLL C (TRICHROMATIC)	0.5	0.5	0.5	0.5	1
PHEOPHYTIN A, SPECTRO (UG/L)	0.83	0.83	0.83	0.83	1
PHEOPHYTIN RATIO(OD663)SPECTRO,BEF/AFT ACID(FLUORO)	1.38	1.38	1.38	1.38	1
THALLIUM, SEDIMENT (MG/KG DRY WT)	5	5	5	5	1
PENTACHLOROPHENOL, SEDIMENT (UG/KG DRY WT)	90	90	90	90	1
ALDRIN, SEDIMENT (UG/KG DRY WT)	20	20	20	20	1
CHLORDANE TECH MIX & METABS, SEDIMENT(UG/KG DRY WT)	70	70	70	70	1
DDD, SEDIMENT (UG/KG DRY WT)	30	30	30	30	1
DDE, SEDIMENT (UG/KG DRY WT)	40	40	40	40	1
P-P' DDT, SEDIMENT (UG/KG DRY WT)	20	20	20	20	1
DIELDRIN, SEDIMENT (UG/KG DRY WT)	20	20	20	20	1
ENDRIN, SEDIMENT (UG/KG DRY WT)	40	40	40	40	1
TOXAPHENE, SEDIMENT (UG/Kg)	140	140	140	140	1
HEPTACHLOR, SEDIMENT (UG/Kg)	20	20	20	20	1
PCBS TOTAL,SEDIMENT (UG/KG DRY WT)	20	20	20	20	1
630 OPTICAL PATH DENSITY BEFORE ADDITION OF HCl	0.01	0.01	0.01	0.01	1
647 OPTICAL PATH DENSITY BEFORE ADDITION OF HCl	0.01	0.01	0.01	0.01	1
664 OPTICAL PATH DENSITY BEFORE ADDITION OF HCl	0.03	0.03	0.03	0.03	1
665 OPTICAL PATH DENSITY BEFORE ADDITION OF HCl	0.02	0.02	0.02	0.02	1
PHOSPHORUS, IN TOTAL ORTHOPHOSPHATE (MG/L AS P)	0.07	0.07	0.07	0.07	1
MERCURY, SEDIMENT (MG/KG AS HG DRY WT)	0.1	0.1	0.1	0.1	1

Parameter	Minimum	Maximum	Average	Median	Number of Observations
VOLUME FILTERED REPORTED IN LITERS	0.3	0.3	0.3	0.3	1
HEPTACHLOR EPOXIDE, SED (UG/KG DRY WT)	20	20	20	20	1
750 OPTICAL PATH DENSITY BEFORE ADDITION OF HCl	0.01	0.01	0.01	0.01	1
750 OPTICAL PATH DENSITY BEFORE ADDITION OF HCl	0.01	0.01	0.01	0.01	1
DICOFOL (KELTHANE)	90	90	90	90	1
PERCENT SAND IN SEDIMENT (%DRY WT)	68.1	68.1	68.1	68.1	1
SEDIMENT PARTICLE SIZE SILT (%DRY WT)	20.4	20.4	20.4	20.4	1
SEDIMENT PARTICLE SIZE CLAY (%DRY WT)	11.5	11.5	11.5	11.5	1
CELL PATH (CM)	5	5	5	5	1
CHLOROPHYLL EXTRACT VOLUME (ML)	10	10	10	10	1

Table 3.5 Monitoring Summary for Ash Camp Creek - 4AACC002.60 (Period of Record: 7/11/1968-6/6/1979 and 9/20/2001-12-/11/2002). Water quality data collected during biomonitoring field visits are summarized in Table 3.6 (bottom)

Parameter	Minimum	Maximum	Average	Median	Number of Observations
DISSOLVED OXYGEN (MG/L) PROBE	5.4	13.82	10.85	11.37	7
FIELD PH	6	8.6	7.23	7.3	98
X-SEC. LOC., VERTICAL (% OF TOTAL DEPTH)	0	50	47.09	50	86
BOD5 (MG/L)	1	16	2.95	2	49
COD (MG/L)	6	6	6	6	1
PH, LAB (SU)	6.7	7.7	7.17	7.1	9
ALKALINITY (MG/L AS CA CO3)	42	97	61.67	54	9
TOTAL SOLIDS, (MG/L)	80	1317	249.38	182.5	52
VOLATILE SOLIDS (MG/L)	5	800	67.26	49	53
FIXED SOLIDS (MG/L)	42	1148	160.16	116	53
DISSOLVED SOLIDS, TOTAL (MG/L)	0.07	0	0.07	0.07	1
TOTAL SUSPENDED SOLIDS (MG/L)	1	111	15.76	7	58
VOLATILE SUSPENDED SOLIDS (MG/L)	0	92	7.67	4	55
FIXED SUSPENDED SOLIDS (MG/L)	0	100	9.37	3	52
AMMONIA, TOTAL (MG/L AS N)	0.01	2	0.2	0.1	69
NITRITE, TOTAL (MG/L AS N)	0.01	0.15	0.02	0.01	68
NITRATE, TOTAL (MG/L AS N)	0.01	1.97	0.3	0.2	57
NITROGEN, TOTAL KJELDAHL (MG/L AS N)	0.1	3.7	0.65	0.4	70
NITRITE + NITRATE, TOTAL (MG/L AS N)	0.04	0.9	0.45	0.59	11
PHOSPHATE, ORTHO (MG/L AS PO4)	0.88	5.2	3.07	3.7	5
PHOSPHORUS, TOTAL (MG/L AS P)	0.03	0.12	0.07	0.05	7

Parameter	Minimum	Maximum	Average	Median	Number of Observations
TOTAL ORGANIC CARBON (MG/L AS C)	4	23	9.25	8	32
CHLORIDE, TOTAL (MG/L)	7	7	7	7	1
ARSENIC, TOTAL (UG/L AS AS)	1	5	3.33	3	9
CADMIUM, TOTAL (UG/L AS CD)	1	10	9.25	10	12
CHROMIUM, TOTAL (UG/L AS CR)	10	39.99	11.43	10	21
COPPER, TOTAL (UG/L AS CU)	10	49.99	15.45	10	22
IRON, TOTAL (UG/L AS FE)	609	2520	1371	1299	6
LEAD, TOTAL (UG/L AS PB)	1	32.99	10.33	10	18
MANGANESE, TOTAL (UG/L AS MN)	19.99	379.9	136.94	95.8	7
NICKEL, DISSOLVED (UG/L AS NI)	10	99.99	63.99	99.99	10
ZINC, TOTAL (UG/L AS ZN)	10	389.9	77.77	39.99	33
COLIFORM,TOT (MPN CONF/100ML AT 35C - TUBE 31506)	7	4600000	315194.5 3	11000	17
FECAL COLIFORM (MPNECMED/100 ML)	18	5400	1493.6	490	5
FECAL COLIFORM (MFM-FCBR/100 ML) MEMBRANE FILTER METHOD	10	100000	2890.8	500	75
PHOSPHATE, TOTAL, COLORIMETRIC METHOD (MG/L AS P)	0.1	2.2	0.36	0.2	58
PHOSPHORUS, IN TOTAL ORTHOPHOSPHATE (MG/L AS P)	0.01	1.8	0.27	0.13	62
MERCURY, TOTAL (UG/L AS HG)	0.3	0.8	0.51	0.5	19
CALCIUM, TOTAL (UG/L AS CA)	10.9	13.5	12.2	12.2	2
MAGNESIUM, TOTAL (UG/L AS MG)	4.78	5.11	4.95	4.95	2
POTASSIUM, TOTAL (UG/L AS K)	1.85	2.02	1.94	1.94	2
SODIUM, TOTAL (UG/L AS NA)	8.14	12.5	10.32	10.32	2

Table 3.6 Monitoring Summary for Ash Camp Creek - 4AACC002.60 (Period of Record: 9/20/2001 - 12/11/2002)

Parameter	Minimum	Maximum	Average	Median	Number of Observations
DISSOLVED OXYGEN (MG/L) PROBE	5.4	13.82	10.85	11.37	7
FIELD PH	6	8.6	7.23	7.3	98
X-SEC. LOC., VERTICAL (% OF TOTAL DEPTH)	0	50	47.09	50	86
BOD5 (MG/L)	1	16	2.95	2	49
COD (MG/L)	6	6	6	6	1
PH, LAB (SU)	6.7	7.7	7.17	7.1	9
ALKALINITY (MG/L AS CA CO3)	42	97	61.67	54	9
TOTAL SOLIDS, (MG/L)	80	1317	249.38	182.5	52
VOLATILE SOLIDS (MG/L)	5	800	67.26	49	53
FIXED SOLIDS (MG/L)	42	1148	160.16	116	53
DISSOLVED SOLIDS, TOTAL (MG/L)	0.07	0	0.07	0.07	1
TOTAL SUSPENDED SOLIDS (MG/L)	1	111	15.76	7	58

Parameter	Minimum	Maximum	Average	Median	Number of Observations
VOLATILE SUSPENDED SOLIDS (MG/L)	0	92	7.67	4	55
FIXED SUSPENDED SOLIDS (MG/L)	0	100	9.37	3	52
AMMONIA, TOTAL (MG/L AS N)	0.01	2	0.2	0.1	69
NITRITE, TOTAL (MG/L AS N)	0.01	0.15	0.02	0.01	68
NITRATE, TOTAL (MG/L AS N)	0.01	1.97	0.3	0.2	57
NITROGEN, TOTAL KJELDAHL (MG/L AS N)	0.1	3.7	0.65	0.4	70
NITRITE + NITRATE, TOTAL (MG/L AS N)	0.04	0.9	0.45	0.59	11
PHOSPHATE, ORTHO (MG/L AS PO4)	0.88	5.2	3.07	3.7	5
PHOSPHORUS, TOTAL (MG/L AS P)	0.03	0.12	0.07	0.05	7
TOTAL ORGANIC CARBON (MG/L AS C)	4	23	9.25	8	32
CHLORIDE, TOTAL (MG/L)	7	7	7	7	1
ARSENIC, TOTAL (UG/L AS AS)	1	5	3.33	3	9
CADMIUM, TOTAL (UG/L AS CD)	1	10	9.25	10	12
CHROMIUM, TOTAL (UG/L AS CR)	10	39.99	11.43	10	21
COPPER, TOTAL (UG/L AS CU)	10	49.99	15.45	10	22
IRON, TOTAL (UG/L AS FE)	609	2520	1371	1299	6
LEAD, TOTAL (UG/L AS PB)	1	32.99	10.33	10	18
MANGANESE, TOTAL (UG/L AS MN)	19.99	379.9	136.94	95.8	7
NICKEL, DISSOLVED (UG/L AS NI)	10	99.99	63.99	99.99	10
ZINC, TOTAL (UG/L AS ZN)	10	389.9	77.77	39.99	33
COLIFORM,TOT (MPN CONF/100ML AT 35C - TUBE 31506)	7	4600000	315194.5 3	11000	17
FECAL COLIFORM (MPNECMED/100 ML)	18	5400	1493.6	490	5
FECAL COLIFORM (MFM-FCBR/100 ML) MEMBRANE FILTER METHOD	10	100000	2890.8	500	75
PHOSPHATE, TOTAL, COLORIMETRIC METHOD (MG/L AS P)	0.1	2.2	0.36	0.2	58
PHOSPHORUS, IN TOTAL ORTHOPHOSPHATE (MG/L AS P)	0.01	1.8	0.27	0.13	62
MERCURY, TOTAL (UG/L AS HG)	0.3	0.8	0.51	0.5	19
CALCIUM, TOTAL (UG/L AS CA)	10.9	13.5	12.2	12.2	2
MAGNESIUM, TOTAL (UG/L AS MG)	4.78	5.11	4.95	4.95	2
POTASSIUM, TOTAL (UG/L AS K)	1.85	2.02	1.94	1.94	2
SODIUM, TOTAL (UG/L AS NA)	8.14	12.5	10.32	10.32	2
Biomonitoring Field Data (5/8/2002 and 9/30/2002)					
Parameter	**5/8/2002**	**9/30/2002**	**Average**		**Number of Observations**
DO	8.48	7.5	8		2
pH	7.25	7.3	7.3		2
H20 TEMPERATURE	20.3	20.8	20.6		2
CONDUCTIVITY	133	160	146.5		2

Table 3.7 Monitoring Summary for Ash Camp Creek - 4AACC004.87 (Period of Record: 9/20/2001-12/11/2002)

Parameter	Minimum	Maximum	Average	Median	Number of Observations
DISSOLVED OXYGEN (MG/L) PROBE	8.2	14.19	11.96	12.47	7
FIELD PH	6.97	7.96	7.34	7.29	7
BOD5 (MG/L)	2	2	2	2	4
TOTAL SUSPENDED SOLIDS (MG/L)	3	30	7	3	7
AMMONIA, TOTAL (MG/L AS N)	0.04	0.14	0.06	0.04	6
NITRITE, TOTAL (MG/L AS N)	0.01	0.01	0.01	0.01	6
NITRATE, TOTAL (MG/L AS N)	0.07	1.46	0.79	0.84	6
NITROGEN, TOTAL KJELDAHL (MG/L AS N)	0.2	0.4	0.27	0.3	7
PHOSPHORUS, TOTAL (MG/L AS P)	0.03	0.08	0.07	0.07	7
FECAL COLIFORM (MPNECMED/100 ML)	20	700	202	40	5
PHOSPHORUS, IN TOTAL ORTHOPHOSPHATE (MG/L AS P)	0.02	0.07	0.05	0.05	6
TURBIDITY FTU - HACH TURBIDIMETER	5.3	22.4	13.85	13.85	2
CONDUCTIVITY	163	233	198	198	2
TOTAL SOLIDS, (MG/L)	144	152	148	148	2
VOLATILE SOLIDS (MG/L)	36	38	37	37	2
FIXED SOLIDS (MG/L)	108	114	111	111	2
VOLATILE SUSPENDED SOLIDS (MG/L)	3	6	4.5	4.5	2
FIXED SUSPENDED SOLIDS (MG/L)	3	24	13.5	13.5	2
COPPER, TOTAL (UG/L AS CU)	10	10	10	10	2
IRON, TOTAL (UG/L AS FE)	380	1910	1145	1145	2
MANGANESE, TOTAL (UG/L AS MN)	53.6	152	102.8	102.8	2
NICKEL, DISSOLVED (UG/L AS NI)	10	10	10	10	2
ZINC, TOTAL (UG/L AS ZN)	11.6	12.5	12.05	12.05	2
FECAL COLIFORM (MFM-FCBR/100 ML) MEMBRANE FILTER METHOD	500	500	500	500	1
CALCIUM, TOTAL (UG/L AS CA)	12.5	17.4	14.95	14.95	2
MAGNESIUM, TOTAL (UG/L AS MG)	4.16	5.09	4.63	4.63	2

Parameter	Minimum	Maximum	Average	Median	Number of Observations
POTASSIUM, TOTAL (UG/L AS K)	2.21	2.47	2.34	2.34	2
SODIUM, TOTAL (UG/L AS NA)	12.7	19.5	16.1	16.1	2
Biomonitoring Field Data (6/21/2002 and 9/30/2002)					
Parameter	**6/21/2002**	**9/30/2002**	**Average**		**Number of Observations**
DO	8.5	10.1	9.3		2
pH	7.3	7.7	7.5		2
H20 TEMPERATURE	21.8	18.9	20.4		2
CONDUCTIVITY	240	260	250		2

Table 3.8 Biomonitoring Field Data for Ash Camp Creek - 4AACC007.62

Parameter	7/3/2002	9/30/2002	Average	Number of Observations
DISSOLVED OXYGEN (MG/L)	6.8	7.6	7.2	2
PH	7.4	7	7.2	2
WATER TEMPERATURE	26.6	22.8	24.7	2
CONDUCTIVITY	563	550	556.5	2

3.4.2 Water Quality Summary Plots

Selected parameters was plotted to examine spatial trends and to compare to reference stream conditions (Figures 3.1 through 3.7). Data collected at AWQM stations since 2001 are shown in these figures. Water quality data collected during biomonitoring field visits were not included in these plots. Median values are shown along with the maximum and minimum values for the period of record. Temperature and pH values for Ash Camp Creek met established water quality standards. TSS and nutrient levels were generally higher at the upstream water quality station.

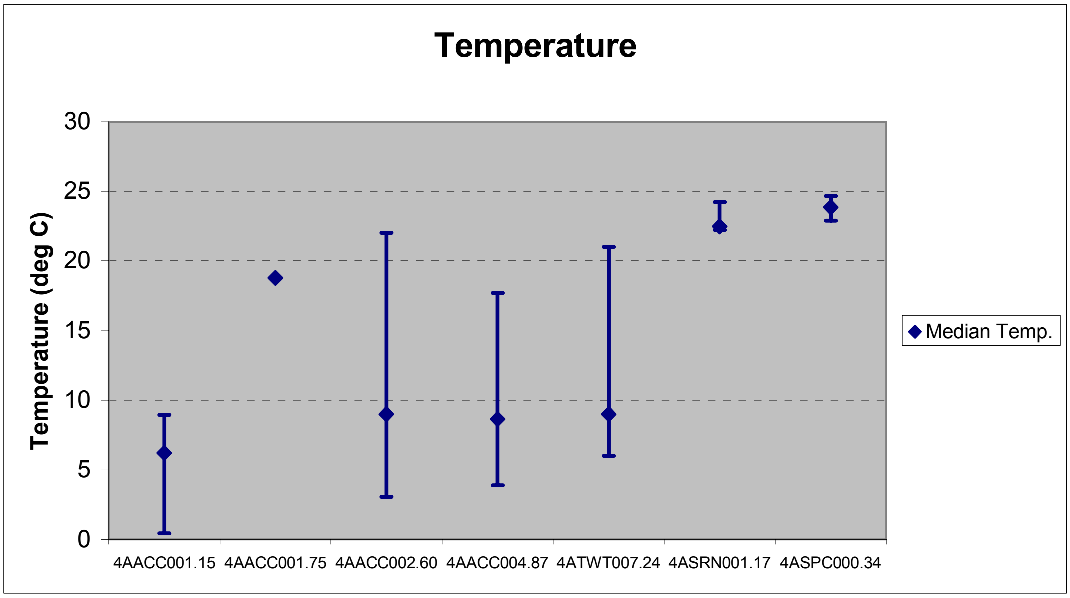

Figure 3.1 Temperature values for Ash Camp Creek and reference streams (Twittys Creek, Spring Creek, and Spencer Creek)

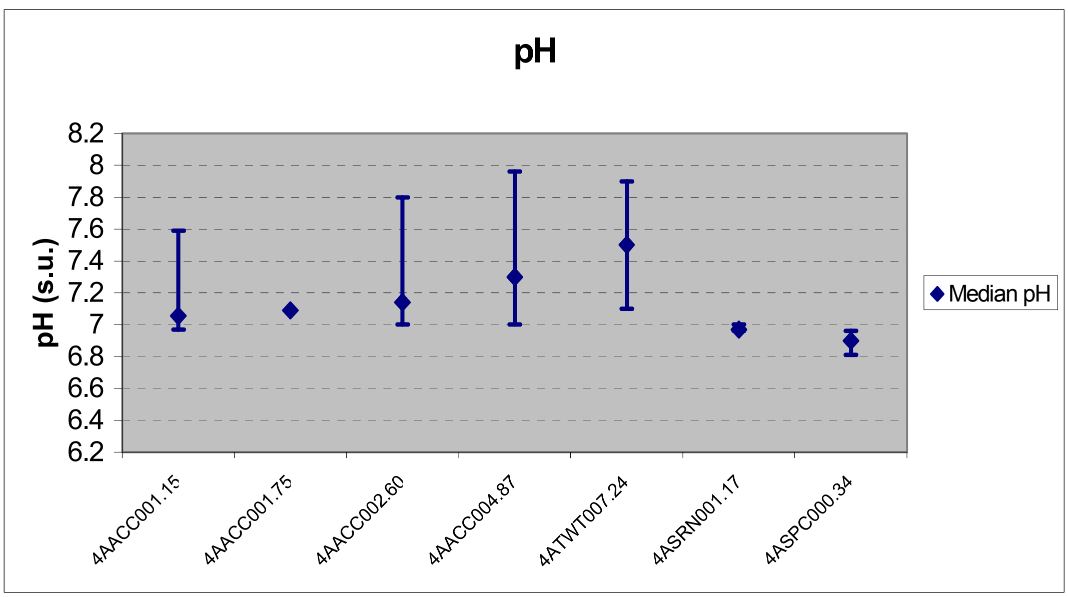

Figure 3.2 pH values for Ash Camp Creek and reference streams (Twittys Creek, Spring Creek, and Spencer Creek)

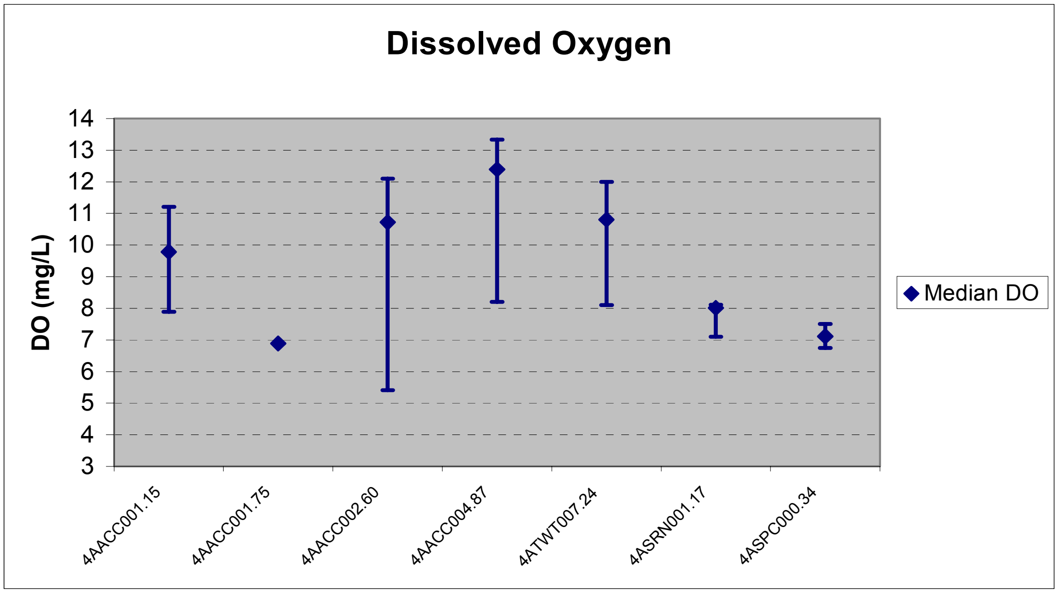

Figure 3.3 DO values for Ash Camp Creek and reference streams (Twittys Creek, Spring Creek, and Spencer Creek)

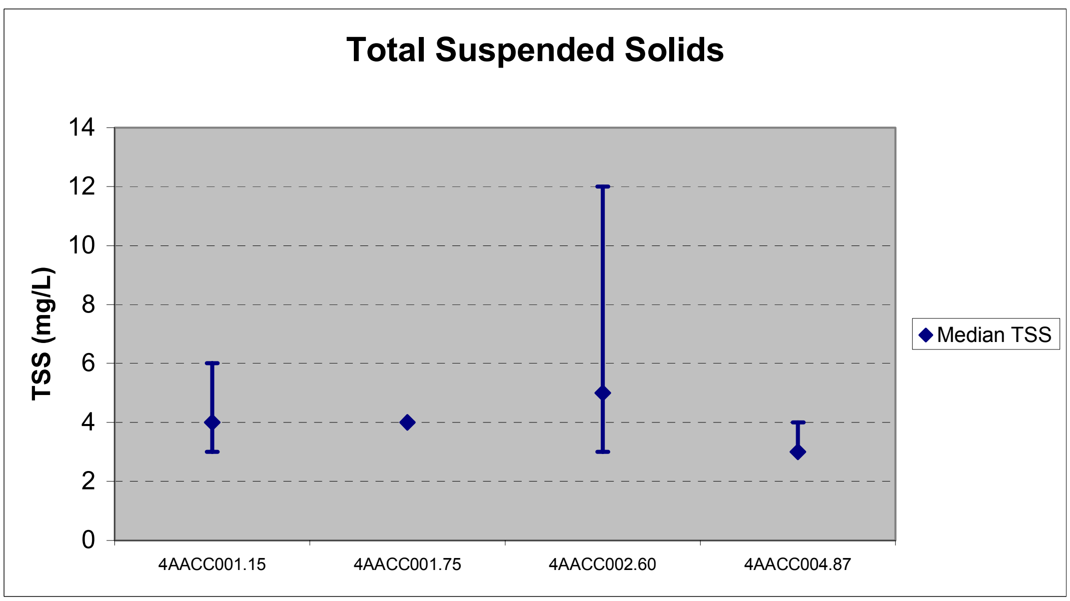

Figure 3.4 TSS values for Ash Camp Creek stations

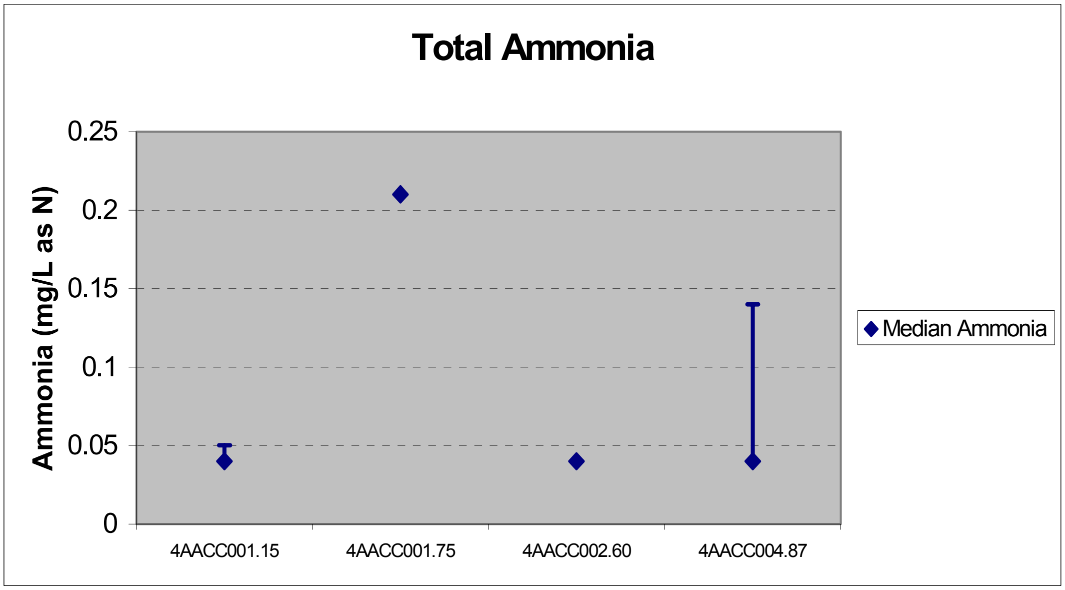

Figure 3.5 Ammonia values for Ash Camp Creek stations

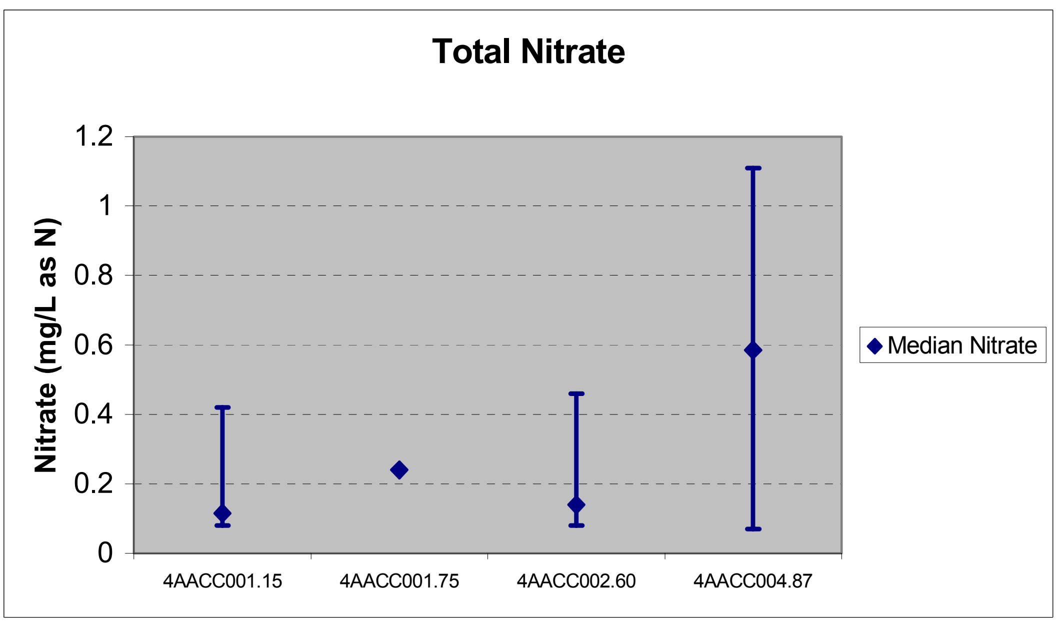

Figure 3.6 Nitrate values for Ash Camp Creek stations

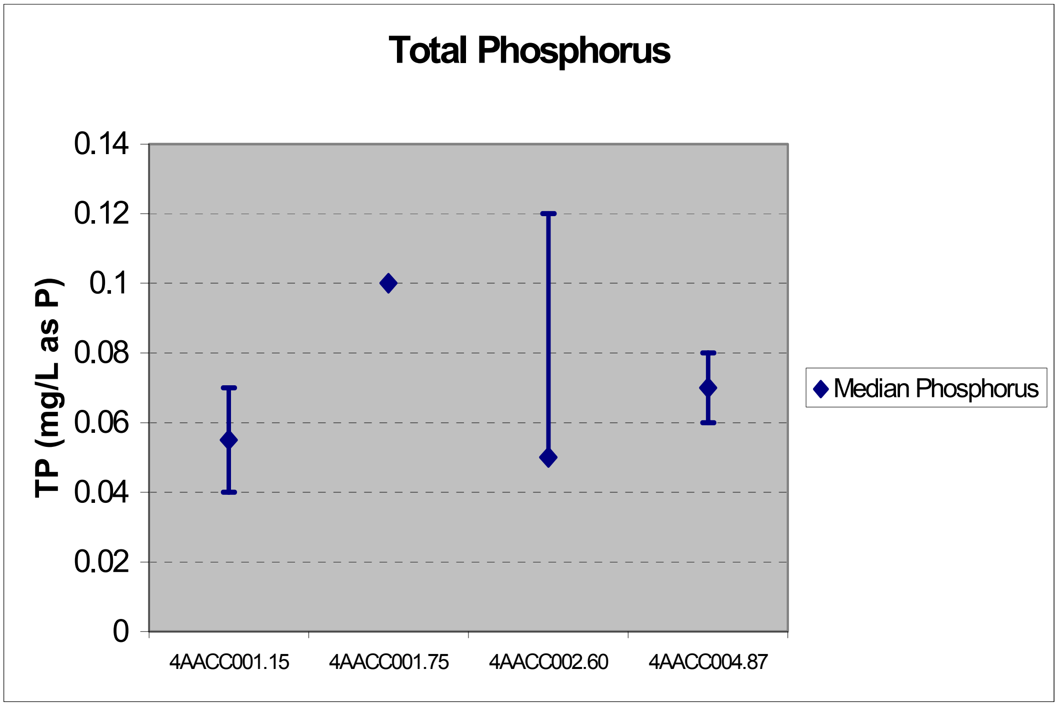

Figure 3.7 Total phosphorus values for Ash Camp Creek stations

Station 4AACC001.75 often showed the poorest water quality, however this station was only sampled on one occasion (May 8, 2002) and none of the other stations had water quality measurements on that same day for comparison. In general, station 4AACC002.60 indicates poorer water quality than the other two stations on Ash Camp Creek that were sampled in 2001-2002. This station had the highest TSS, TP, and TKN concentrations and the lowest DO concentrations. This station is located directly below a large agricultural area that is believed to contribute excessive sedimentation and other pollutants to the stream. Land use in the Ash Camp Creek watershed is shown in Section 2. The watershed primarily consists of forest land and pasture/hay land.

3.4.3 DO Analysis

Primary producers (algae and macrophytes) produce oxygen during the day through photosynthesis and use oxygen at night through respiration. This diel photosynthesis/respiration cycle results in higher DO concentrations during the day and lower concentrations at night. The special study conducted in 2001/2002 indicated possible low DO conditions in Ash Camp Creek near the mouth, which is an area characterized by wetlands and slower-moving water that is expected to have naturally low levels of DO. AWQM DO data collected at each station were compared to the daily average (5.0 mg/L) and minimum (4 mg/L) DO criteria listed in Virginia's Water Quality Standards to help determine if DO conditions are considered to be a primary cause of the benthic impairment (Figure 3.3). There were no ambient observations below the 5.0 mg/L daily average criteria. The lowest DO concentration recorded (5.4 mg/L) was observed in September 2001 at station 4AACC002.60.

To further investigate the potential for low DO conditions in Ash Camp Creek, VADEQ conducted 24-hour dissolved oxygen monitoring at several locations on Ash Camp Creek and nearby reference streams on August 14-15, 2003 (Table 3.8). DO conditions are typically lowest during summer months in the early morning hours due to higher temperatures and lower flow. These data did not show observations below the 5.0 mg/L daily average criteria for all Ash Camp Creek and reference stations.

Table 3.9 VADEQ Diurnal DO study (Summer 2003)

Date	Time	DO (mg/l)	Temperature (C)	pH (s.u.)	Specific Conductivity (µs/sec)
4ACC004.87 - Ash Camp Creek at Conservation Road Bridge					
8/14/2003	3:30 PM	7.96	23.04	7.36	155.8
8/14/2003	7:10 PM	7.92	23.16	7.17	157.1
8/15/2003	7:00 AM	7.84	21.12	7.25	156.4
4ACC002.60 - Ash Camp Creek at Route 654 Bridge					
8/14/2003	3:45 PM	6.82	25.63	7.26	143.3
8/14/2003	5:00 PM	6.62	25.94	7.25	141.3
8/14/2003	7:41 PM	6.82	25.35	7.13	142.2
8/14/2003	9:15 PM	6.02	24.64	7.05	144.4
8/14/2003	10:51PM	6.13	24.18	7.08	143.1
8/15/2003	12:28 AM	5.93	23.66	7.10	142.5
8/15/2003	2:00 AM	6.15	23.13	7.09	145.6
8/15/2003	3:29 AM	6.43	22.85	7.11	140.4
8/15/2003	4:55 AM	6.17	22.49	7.13	142.1
8/15/2003	7:35 AM	7.64	21.95	7.16	141.4
8/15/2003	9:45 AM	7.87	21.97	7.15	139.7
8/15/2003	11:00 AM	8.13	22.56	7.19	139.5
8/15/2003	12:25 PM	8.56	23.72	7.28	138.0
TWT007.24 -Twitty's Creek Reference (25 feet downstream of low head dam)					
8/14/2003	2:00 PM	6.85	24.87	7.37	90.1
8/14/2003	3:00 PM	6.86	25.21	7.22	90.3
8/14/2003	4:00 PM	6.76	25.43	7.21	90.3
8/14/2003	5:00 PM	6.72	25.56	7.21	90.4
8/14/2003	6:00 PM	6.68	25.71	7.21	90.1
8/14/2003	7:00 PM	6.60	25.76	7.19	90.3
8/14/2003	8:00 PM	6.53	25.79	7.19	90.0
8/14/2003	9:00 PM	6.45	25.75	7.18	90.1
8/14/2003	10:00 PM	6.40	25.69	7.18	90.5
8/14/2003	11:00 PM	6.43	25.61	7.17	90.3
8/15/2003	12:00 AM	6.38	25.5	7.16	90.1
8/15/2003	1:00 AM	6.47	25.34	7.15	90.1
8/15/2003	2:00 AM	6.39	25.16	7.15	90.3
8/15/2003	3:00 AM	6.41	24.97	7.15	90.6
8/15/2003	4:00 AM	6.45	24.77	7.14	90.6
8/15/2003	5:00 AM	6.47	24.58	7.14	90.6
8/15/2003	6:00 AM	6.46	24.43	7.14	90.8
8/15/2003	7:00 AM	6.41	24.32	7.14	91.0
8/15/2003	8:00 AM	6.45	24.25	7.14	91.1
8/15/2003	9:00 AM	6.45	24.21	7.14	91.1
8/15/2003	10:00 AM	6.46	24.24	7.14	91.3
8/15/2003	11:00 AM	6.46	24.37	7.15	91.5
8/15/2003	12:00 PM	6.46	24.54	7.15	92.3
4ASPC000.34 - Spencer Creek (Ash Camp Creek reference)					
8/14/2003	3:15 PM	7.10	24.37	6.96	79.9
8/14/2003	4:50 PM	6.97	24.61	6.96	79.9
8/14/2003	7:25 PM	7.14	24.66	6.88	80.4
8/14/2003	8:55 PM	6.98	24.50	6.81	80.4
8/14/2003	10:35 PM	7.06	24.36	6.88	80.9
8/15/2003	12:10 AM	7.18	24.13	6.90	80.9
8/15/2003	1:45 AM	7.11	23.84	6.87	81.0
8/15/2003	3:17 AM	6.74	23.58	6.91	81.0
8/15/2003	4:40 AM	7.08	23.34	6.93	81.4
8/15/2003	7:24 AM	7.35	22.90	6.94	82.3
8/15/2003	9:32 AM	7.42	22.91	6.87	82.5
8/15/2003	10:50 AM	7.51	23.19	6.89	82.9
8/15/2003	12:08 PM	7.50	23.70	6.90	82.7
4ASRN001.17 - Spring Creek (Ash Camp Creek reference)					
8/14/2003	7:31 PM	7.10	24.22	6.99	88.0
8/15/2003	7:18 AM	7.58	22.28	7.00	89.7
8/15/2003	9:18 AM	8.01	22.24	6.97	89.6
8/15/2003	10:45 AM	8.04	22.48	6.97	89.7
8/15/2003	12:02 PM	8.11	22.95	6.96	89.5

3.4.4 Sedimentation and Habitat Alteration

Total suspended solids (TSS) data, habitat data collected during biomonitoring site visits, and field observations made during TMDL site visits were used to examine the likelihood of sedimentation impacts on the benthic community in Ash Camp Creek. Station 4AACC002.60 had the highest TSS concentrations recorded. This station is located directly below a large agricultural area that is believed to contribute excessive sedimentation and other pollutants to the stream. Minimal riparian vegetation and eroded streambanks were noted upstream of this station during TMDL site visits. Rapid Bioassessment Protocol (RBP) habitat data for Ash Camp Creek and Twittys Creek biomonitoring stations are shown in Table 3.9. All habitat scores were evaluated and rated by observation (0-20 scoring, higher score is better). Overall, there is no clear trend in the habitat assessment data, given the information available. Ash Camp Creek scored lower than Twittys Creek for the parameters: embeddedness, bank stability, bank vegetative protection, and instream cover. Twittys Creek scored lower than Ash Camp Creek for the parameters: channel alteration, frequency of riffles, riparian zone width, and velocity/depth regime. Both streams had equivalent scores for channel flow status and sediment deposition.

Table 3.10 RBP habitat scores for Ash Camp Creek and Twittys Creek

Station ID	Collection Date	Channel Alteration	Bank Stability	Bank Vegetative Protection	Instream Cover	Embed-dedness	Channel Flow Status	Frequency of Riffles	Riparian Vegetation Zone Width	Sediment Deposition	Velocity/ Depth Regime
Ash Camp Creek											
4AACC002.60	5/8/2002	20	10	12	9	4	8	11	20	8	9
Twittys Creek Watershed											
4ATWT008.59	7/2/2002	16	12	14	10	8	8	10	18	8	4
4ATWT008.59	10/3/2002	16	12	14	10	8	8	10	18	8	4

3.5 Toxic Pollutants - Surface Water

Virginia Water Quality Standards list acute and chronic criteria for surface waters (9 VAC 25-260-140). These numeric criteria were developed for metals, pesticides, and other toxic chemicals which can cause acute and chronic toxicity effects on aquatic life and human health. Available water quality data were compared to these criteria to determine possible effects on aquatic life. Ammonia ($NH3+NH4$) is a critical component of the nitrogen cycle. At high concentrations, ammonia is toxic to aquatic life, depending on pH and temperature levels. In general, the higher the temperature and pH levels, the more toxic ammonia is to aquatic life. Virginia Water Quality Standards (9 VAC 25-260-155) specify the formulas that are used to calculate the acute and chronic criteria values for ammonia depending on stream type (freshwater or saltwater), temperature, and pH levels, and the expected presence or absence of trout. Ammonia data collected on Ash Camp Creek were compared to the calculated acute and chronic criteria using pH and temperature data collected at the same time. For the period of record at each AWQM station, there were no exceedances of these criteria, however, the highest concentrations were noted at the AWQM station nearest to the Keysville STP discharge (4AACC004.87). The highest single observation was recorded at the DEQ probabilistic monitoring station, 4AACC001.75.

For the data collected from 2001 to present, there were no exceedances of the respective water column and sediment criteria for toxic constituents. Samples collected during the 1970s for 4AACC002.60 do show high concentrations for Total Copper and Total Zinc. Several observations exceeded the dissolved acute and chronic metals criteria (Figures 3.8 and 3.9).

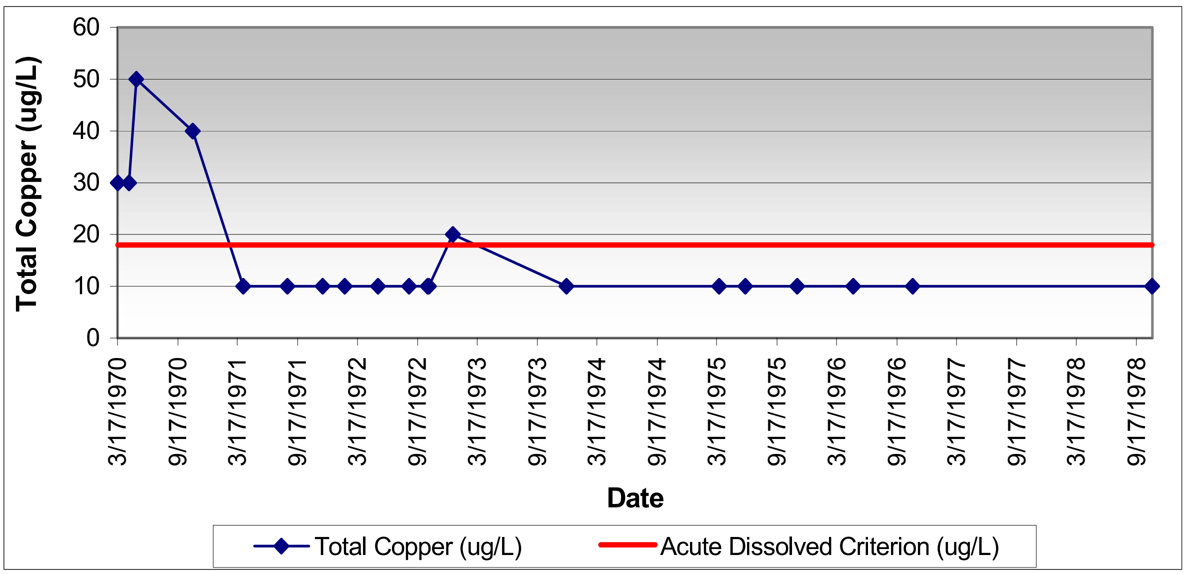

Figure 3.8 Total copper observations at station 4AACC002.60 (3/17/70 through 9/17/78)

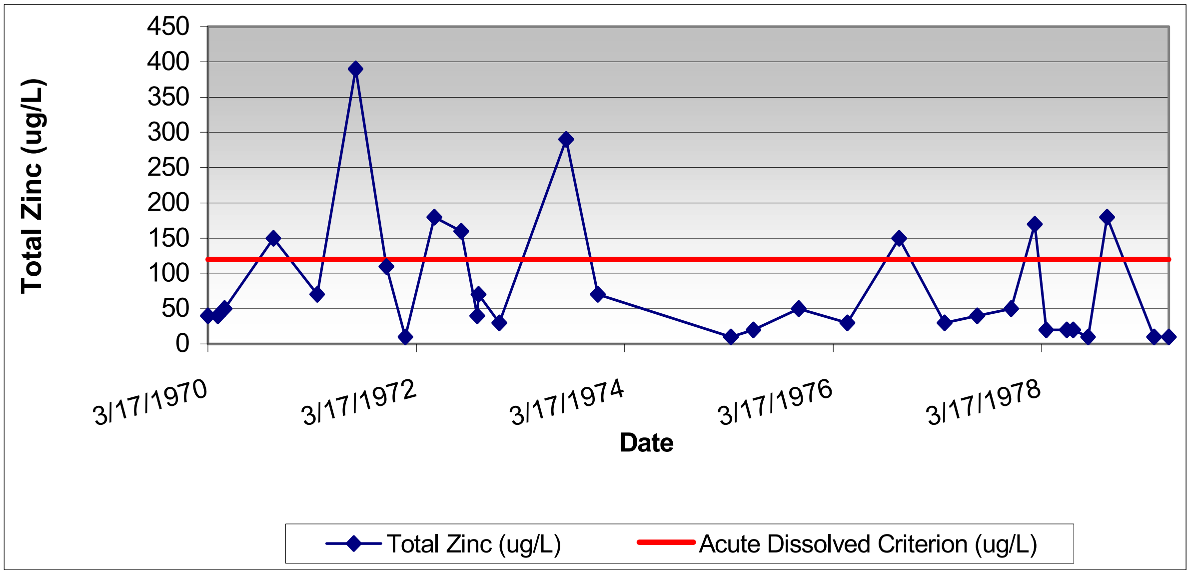

Figure 3.9 Total zinc observations at station 4AACC002.60 (3/17/70 through 9/17/78)

3.6 Toxic Pollutants - Sediment

Virginia's Water Quality Standards and updated 305(b) assessment guidance for sediment parameters were consulted to determine if the available data indicate high levels for metals, pesticides, or other constituents that can cause acute or chronic toxicity effects on aquatic life. Water column data were compared to established Water Quality Standards numeric criteria (9 VAC 25-260-140) and sediment data were compared to EPA Probable Effects Concentration (PEC) criteria and NOAA Effects Range-Median (ER-M) and Effects Range-Low (ER-L) thresholds (refer to Table 3.10 for sediment criteria).

Table 3.11 Sediment Threshold Criteria

Parameter	PEC	ER-M	ER-L
SILVER, SEDIMENT (MG/KG AS AG DRY WT)	2.6	3.7	1
ARSENIC, SEDIMENT (MG/KG DRY WT)	33	70	8.2
CADMIUM, SEDIMENT (MG/KG DRY WT)	4.98	9.6	1.2
CHROMIUM, SEDIMENT (MG/KG DRY WT)	111	370	81
COPPER, SEDIMENT (MG/KG AS CU DRY WT)	149	270	34
MERCURY, SEDIMENT (MG/KG AS HG DRY WT)	1.06	0.71	0.15
NICKEL, SEDIMENT (MG/KG DRY WT)	48.6	51.6	20.9
LEAD, SEDIMENT (MG/KG AS PB DRY WT)	128	223/218	46.7
ZINC, SEDIMENT (MG/KG AS ZN DRY WT)	459	410	150
SUM PAH, DRY WEIGHT BASIS (ppb)	NA	44792	4022
TOTAL PAH, DRY WEIGHT BASIS (ppb)	22800	44792	4022
NAPHTHALENE	561	2100	160
NAPHTHALENE, 2-METHYL	NA	670	70

Parameter	PEC	ER-M	ER-L
ACENAPHTHLYENE	121	640	44
ACENAPHTHENE	170	500	16
FLOURENE	536	540	19
PHENANTHRENE	1170	1500	240
ANTHRACENE	845	1100	85.3
FLUORANTHENE	2230	5100	600
PYRENE	1520	2600	665
BENZ(A)ANTHRACENE	1050	1600	261
CHRYSENE	1290	2800	384
BENZO(a)PYRENE	1450	1600	430
DIBENZ(a,h)ANTHRACENE	318	260	63.4
SUM PAH	NA	44792	4022
Total PAH, DRY WEIGHT BASIS (ppb)	22800	44792	4022
PAH	Low mol wt	3160	552
PAH	High mol wt	9600	1700
PCB	676	180	22.7
CHLORDANE	17.6	6	0.5
SUM DDE	31.3	27	2.2
SUM DDD	28	20	2
SUM DDT	62.9	7	1
TOTAL DDT	572	46.1	1.58
ENDRIN	207	NA	NA
HEPTACHLOR EPOXIDE	16	NA	NA

3.7 EPA Toxicity Testing

Toxicity tests were conducted by EPA Region 3 to determine possible toxic effects on aquatic organisms in these streams (USEPA 2003b). Water (grab) samples were collected by VADEQ at two stations on Ash Camp Creek (4AACC002.60 and 4AACC004.87) on December 9, 11, and 13, 2002. These samples were shipped to the EPA Region 3 lab in Wheeling, West Virginia for processing. The survival/growth of fathead minnows (*Pimephales promelas*) and the survival/reproduction of *Ceriodaphnia dubia* were measured using standard toxicity testing methods.

Acute effects were not observed for either test organism. Subchronic effects on minnow growth were noted for samples collected from 4AACC004.87; however, these results were not considered to be biologically significant. The minnow weight difference, as compared to the control, was 20%. Differences of less than 25% may be an artifact of test design and not a result of stream toxicity.

3.8 Point Source Data Analysis

Point sources can contribute sediment loads to surface waters through effluent discharges. These facilities are permitted through the Virginia Pollutant Discharge Elimination System (VPDES) program that is managed by VADEQ. VPDES individual permits are issued to facilities that must comply with permit conditions that include specific discharge limits and requirements. The Keysville STP (VPDES VA0024058) is the only point source facility located in the Ash Camp Creek watershed. This facility discharges to Ash Camp Creek just upstream of the DEQ biomonitoring station 4AACC007.62. Discharge monitoring data indicate episodic exceedances of the current permit limits for metals and ammonia (especially during rainfall events). This facility will be upgraded and expanded in the next two years, which will help alleviate the current discharge problems. The new plant will have a modern digester and is expected to meet permits limits. The current design flow of the facility is 0.250 mgd. The facility has no flow limit and is "monitor only" for flow. Table 3.11 presents the current permit limits for the Keysville STP. This permit was scheduled to expire on June 15, 2003. The new permit was issued 6/15/03 and expires 6/14/08. The upgraded facility will have a design flow of 0.5 MGD, but has no flow limit and is "monitor only" for flow. Table 3.12 presents the permit limits for the upgraded Keysville STP that will be in effect once the new facility is online (probably end of 2004 or early 2005).

Table 3.12 Permit limits for the Keysville STP (VA0024058) before 6/15/03

<table>
<tr><th>Parameter</th><th colspan="2">Monthly Average Limit</th><th colspan="2">Weekly Average Limit</th><th>Minimum Limit</th><th colspan="2">Maximum Limit</th></tr>
<tr><td>BOD5</td><td>23.0 mg/L</td><td>22.0 kg/d</td><td>35.0 mg/L</td><td>33.0 kg/d</td><td>—</td><td colspan="2">—</td></tr>
<tr><td>TSS</td><td>30.0 mg/L</td><td>28.0 kg/d</td><td>45.0 mg/L</td><td>43.0 kg/d</td><td>—</td><td colspan="2">—</td></tr>
<tr><td>Ammonia Nitrogen</td><td>1.4 mg/L</td><td>1.3 kg/d</td><td colspan="2">1.4 mg/L</td><td>—</td><td>1.4 mg/L</td><td>1.3 kg/d</td></tr>
<tr><td>Total Recoverable Copper</td><td>18.0 ug/L</td><td>17.0 g/d</td><td colspan="2">18 ug/L</td><td>—</td><td>18.0 ug/L</td><td>17.0 g/d</td></tr>
<tr><td>Total Recoverable Zinc</td><td>122.0 ug/L</td><td>115.0 g/d</td><td colspan="2">122 ug/L</td><td>—</td><td>122.0 ug/L</td><td>115.0 g/d</td></tr>
<tr><td>PH</td><td colspan="2">—</td><td colspan="2">—</td><td>6.0</td><td colspan="2">9.0</td></tr>
<tr><td>Dissolved Oxygen</td><td colspan="2">—</td><td colspan="2">—</td><td>5.0 mg/L</td><td colspan="2">—</td></tr>
</table>

Table 3.13 Permit limits for the upgraded Keysville STP (VA0024058) from 6/15/03 to 6/14/08

Parameter	Monthly Average Limit		Weekly Average Limit		Minimum Limit	Maximum Limit	
cBOD5 (Dec. – Apr)	25.0 mg/L	47.3 kg/d	37.5 mg/L	70.9 kg/d	—	—	
cBOD5 (May –Nov)	17.0 mg/L	32.1 kg/d	25.5 mg/L	48.2 kg/d			
TSS	30.0 mg/L	56.7 kg/d	45.0 mg/L	85.1 kg/d	—	—	
Ammonia Nitrogen (Dec. – Apr)	1.4 mg/L	—	1.4 mg/L		—	—	—
Total Kjeldahl Nitrogen (May –Nov)	4.0 mg/L	—	6.0 mg/L		—	—	—
Total Recoverable Copper	18.0 ug/L	—	18 ug/L		—	—	—
Total Recoverable Zinc	122.0 ug/L	—	122 ug/L		—	—	—
PH	—		—		6.0	9.0	
Total Residual Chlorine	8.0 ug/L		9.8 ug/L		—	—	
Dissolved Oxygen	—		—		5.0 mg/L	—	

Keysville STP effluent data were provided by VADEQ for a range of dates from February 1998 through February 2003. Table 3.13 presents a summary of the facility's effluent data. Data on the number and percent of exceedances was based on comparing effluent data to the permit limits listed in Table 3.11.

Table 3.14 Effluent data at the Keysville STP (VA0024058)

Parameter	Number of Observations	Period of Record	Average	Maximum	Minimum	Number of Permit Exceedances	Percent of Samples Exceeding Permit Limits
Flow (mgd)	46	2/10/99-2/10/03	0.107	0.504	0.045	No Permit Limit	0
PH (SU)	45	5/10/99-2/10/03	N/A	7.8	5.8	1 Exceedance	2
BOD5 (mg/L)	45	5/10/99-2/10/03	9.56	27.97	N/A	No Exceedances	0
TSS (mg/L)	48	2/10/98-2/10/03	18.53	59.00	N/A	4 Exceedances	8

Parameter	Number of Observations	Period of Record	Average	Maximum	Minimum	Number of Permit Exceedances	Percent of Samples Exceeding Permit Limits
DO (mg/L)	44	5/10/99-2/10/03	N/A	N/A	5.1	No Exceedances	0
Ammonia (mg/L)	45	5/10/99-2/10/03	1.49	10.40	N/A	6 Exceedances	13
Zinc (ug/L)	7	8/10/02-2/10/03	63.14	70.00	N/A	No Exceedances	0
Copper (ug/L)	7	8/10/02-2/10/03	20.29	29.00	N/A	3 Exceedances	43

In summary, the Keysville STP showed one exceedance of its pH permit limit and several exceedances of the TSS, ammonia, and copper permit limits. Figures 3.11 through 3.14 present the pH, TSS, ammonia, and copper observations for the Keysville STP effluent. The red lines in each of the following figures represent the appropriate permit limits for each pollutant.

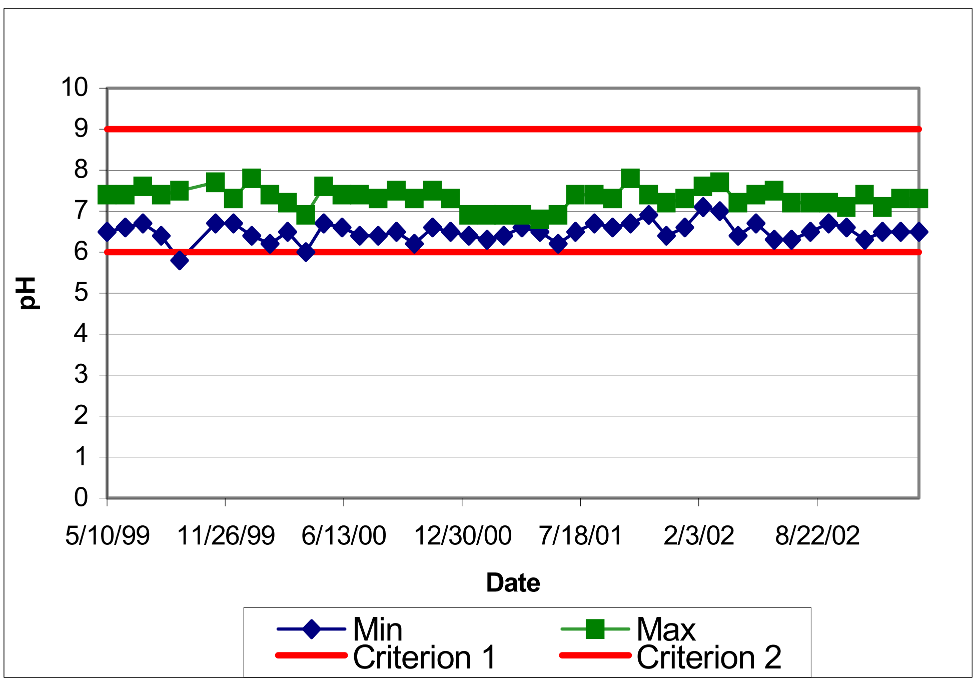

Figure 3.10 pH observations at the Keysville STP outfall

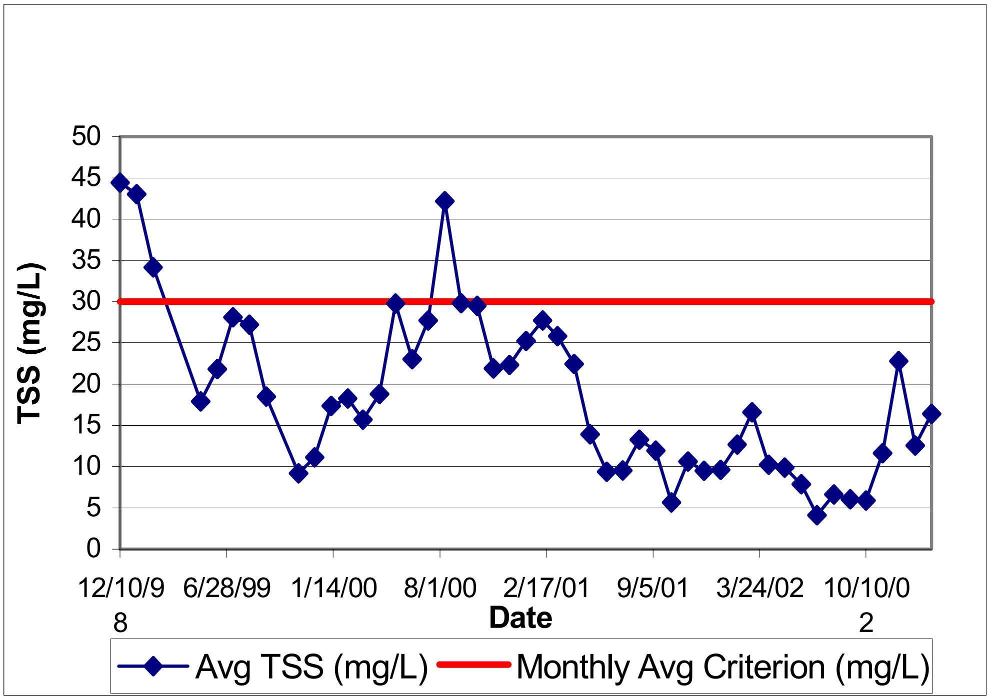

Figure 3.11 TSS observations at the Keysville STP outfall

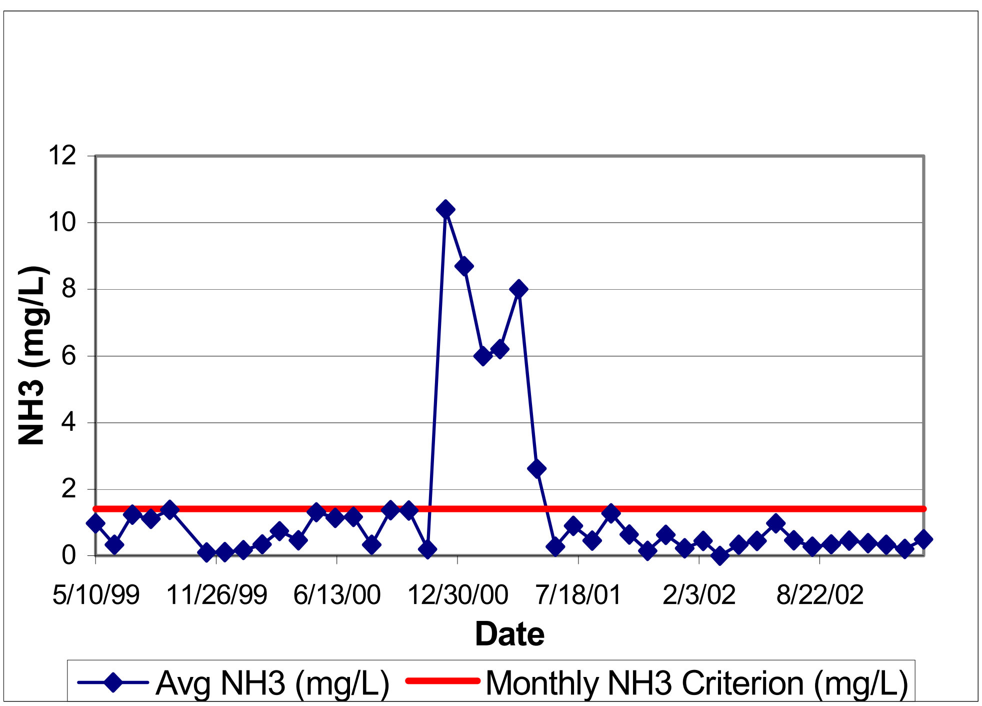

Figure 3.12 Ammonia observations at the Keysville STP outfall

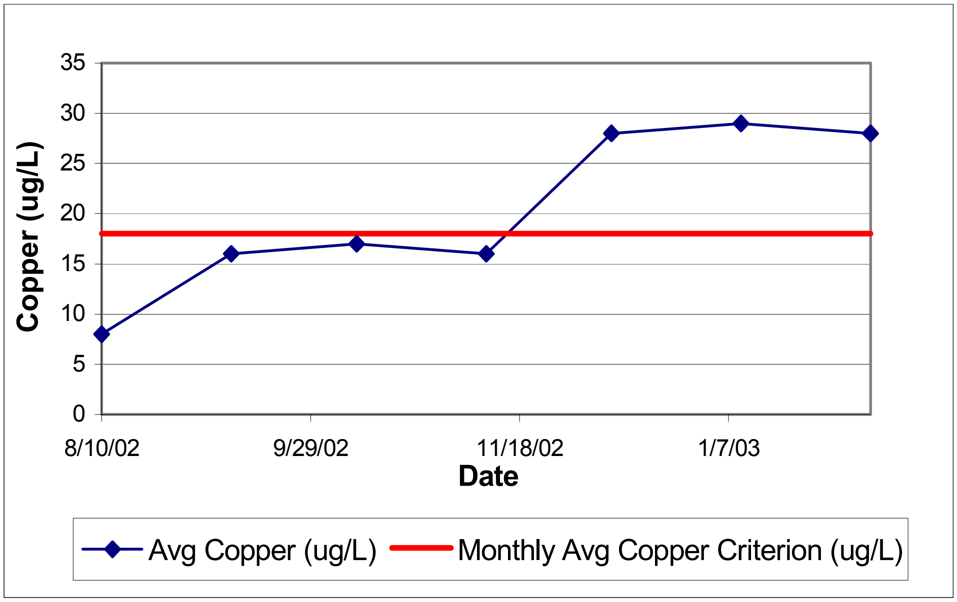

Figure 3.13 Copper observations at the Keysville STP outfall

3.9 Summary

The stressor analysis indicates that excessive sedimentation and Keysville STP discharge problems are the likely causes of impairment to the benthic community in Ash Camp Creek. AWQM and diurnal DO data indicate that DO conditions are adequate to support aquatic life in Ash Camp Creek; however, TSS levels and site visit observations conducted during TMDL development indicate sediment-caused habitat problems. The portion of the watershed above monitoring station 4AACC002.60 is believed to be a major contributor of excess sediment and nutrient loads to the stream due to intensive agricultural use and cattle grazing in the area.

The Keysville STP is currently contributing elevated concentrations of TSS, ammonia, and copper to the stream; however, it is assumed that these pollutants will not be an issue once the facility upgrades are completed over the next few years. Considering the planned upgrade to the Keysville STP, reductions in sediment loading should lead to improved habitat conditions in Ash Camp Creek.

SECTION 4

SOURCE ASSESSMENT - SEDIMENT

Point and nonpoint sources of sediment were assessed in TMDL development. The source assessment was used as the basis of model development and analysis of TMDL allocation options. A variety of information was used to characterize sources in impaired and reference watersheds including: MRLC land use/land cover data, water quality monitoring and point source data provided by VADEQ, STATSGO soils data (NRCS), bank erosion information provided by VADEQ, site visit observations, literature sources, and other information. Procedures and assumptions used in estimating sediment sources in impaired and reference watersheds are described in the following sections. Whenever possible, data development and source characterization was accomplished using locally-derived information.

4.1 Assessment of Nonpoint Sources

Erosion of the land results in the transport of sediment to receiving waters through various processes. Factors that influence erosion include characteristics of the soil, vegetative cover, topography, and climate. Nonpoint sources, such as agricultural land uses and construction areas, are large contributors of sediment because the percentage of vegetative cover is typically lower. Urban areas can also contribute quantities of sediment to surface waters through the build-up and eventual washoff of soil particles, dust, debris, and other accumulated materials. Pervious urban areas, such as lawns and other green spaces contribute sediment in the same fashion as low-intensity pasture areas or other similar land uses. In addition, streambank erosion and scouring processes can result in the transport of additional sediment loads.

4.1.1 Agricultural Land

Agricultural land was identified as a primary source of sediment in the Ash Camp Creek watershed. Agricultural runoff can contribute increased pollutant loads when farm management practices allow soils rich in nutrients from fertilizers or animal waste to be washed into the stream, increasing in-stream sediment and phosphorus levels. The erosion potential of cropland and over-grazed pasture land is particularly high due to the lack of year-round vegetative cover. The use of cover crops and other management practices have been shown to reduce the transport of pollutant loads from agricultural lands.

MRLC land use coverages for the Ash Camp Creek and Twittys Creek watersheds are shown in Section 3.

4.1.2 Forest Land

Agricultural and urban development in these watersheds has replaced some mature forest areas, especially along the stream and at lower elevations. The sediment yield from undisturbed forest lands, especially during the growing season, is low due to the amount of dense vegetative cover which stabilizes soils and reduces rainfall impact.

4.1.3 Urban Areas

Urban land uses represented in the MRLC land use coverage include commercial, industrial, transportation, and residential areas. Urban land uses consist of pervious and impervious areas. Stormwater runoff from impervious areas, such as paved roads and parking lots, contribute pollutants that accumulate on these surfaces directly to receiving waters without being filtered by soil or vegetation. Sediment deposits in impervious areas originate from vehicle exhaust, industrial and commercial activities, outdoor storage piles, and other sources. In addition, stormwater runoff can cause streambank erosion and bottom scouring through high flow volumes, resulting in increased sedimentation and other habitat impacts.

The primary urban sources of sediment are construction sites and other pervious lands. Construction sites have high erosion rates due to the removal of vegetation and top soil. Typical erosion rates for construction sites are 35 to 45 tons per acre per year as compared to 1 to 10 tons per acre per year for cropland. Residential lawns and other green spaces contribute sediment in the same fashion as low-intensity pasture areas or other similar land uses.

Urban land use areas were separated into pervious and impervious fractions based on the estimated percent impervious surface of each urban land use category. Field observations and literature values were used to determine the effective percent imperviousness of urban land uses (Table 4.1).

Table 4.1 Percent imperviousness of urban land uses

Urban land uses	Percent impervious
High Intensity Residential	40%
Low Intensity Residential	20%

4.2 Assessment of Point Sources

Point sources can contribute sediment loads to surface waters through effluent discharges. These facilities are permitted through the Virginia Pollutant Discharge Elimination System (VPDES) program that is managed by VADEQ. VPDES individual permits are issued to facilities that must comply with permit conditions that include specific discharge limits and requirements. The

Keysville STP (VPDES VA0024058) is the only point source facility located in the Ash Camp Creek watershed. This facility discharges to Ash Camp Creek just upstream of the DEQ biomonitoring station 4AACC007.62. The current design flow of the facility is 0.250 MGD. The facility has no flow limit and is "monitor only" for flow. This facility will be upgraded and expanded in the next two years. A permitted TSS concentration of 30 mg/L was used to estimate the sediment load from this facility. Table 4.2 presents the current permit limits for the Keysville STP. This permit was scheduled to expire on June 15, 2003. The new permit was issued 6/15/03 and expires 6/14/08. The upgraded facility will have a design flow of 0.5 MGD, but has no flow limit and is "monitor only" for flow. Table 4.3 presents the permit limits for the upgraded Keysville STP that will be in effect once the new facility is online (probably at the end of 2004 or early 2005).

General permits are granted for smaller facilities, such as domestic sewage discharges, that must comply with a standard set of permit conditions, depending on facility type. Currently, there are no VPDES domestic sewage discharge general permits in the Ash Camp Creek watershed.

Table 4.2 Permit limits for the Keysville STP (VA0024058) before 6/15/03

Parameter	Monthly Average Limit		Weekly Average Limit		Minimum Limit	Maximum Limit	
BOD5	23.0 mg/L	22.0 kg/d	35.0 mg/L	33.0 kg/d	—	—	
TSS	30.0 mg/L	28.0 kg/d	45.0 mg/L	43.0 kg/d	—	—	
Ammonia Nitrogen	1.4 mg/L	1.3 kg/d	1.4 mg/L		—	1.4 mg/L	1.3 kg/d
Total Recoverable Copper	18.0 ug/L	17.0 g/d	18 ug/L		—	18.0 ug/L	17.0 g/d
Total Recoverable Zinc	122.0 ug/L	115.0 g/d	122 ug/L		—	122.0 ug/L	115.0 g/d
PH	—		—		6.0	9.0	
Dissolved Oxygen	—		—		5.0 mg/L	—	

Table 4.3 Permit limits for the upgraded Keysville STP (VA0024058) from 6/15/03 to 6/14/08

Parameter	Monthly Average Limit		Weekly Average Limit		Minimum Limit	Maximum Limit	
cBOD5 (Dec. – Apr)	25.0 mg/L	47.3 kg/d	37.5 mg/L	70.9 kg/d	—	—	
cBOD5 (May –Nov)	17.0 mg/L	32.1 kg/d	25.5 mg/L	48.2 kg/d			
TSS	30.0 mg/L	56.7 kg/d	45.0 mg/L	85.1 kg/d	—	—	
Ammonia Nitrogen (Dec. – Apr)	1.4 mg/L	—	1.4 mg/L		—	—	—
Total Kjeldahl Nitrogen (May –Nov)	4.0 mg/L	—	6.0 mg/L		—	—	—
Total Recoverable Copper	18.0 ug/L	—	18 ug/L		—	—	—
Total Recoverable Zinc	122.0 ug/L	—	122 ug/L		—	—	—
PH	—		—		6.0	9.0	
Total Residual Chlorine	8.0 ug/L		9.8 ug/L		—	—	
Dissolved Oxygen	—		—		5.0 mg/L	—	

SECTION 5

WATERSHED MODELING

5.1 Overall Technical Approach

As discussed in Section 2.1, a reference watershed approach was used in this study to develop TMDLs for Ash Camp Creek. A watershed model and stream module (developed by Tetra Tech, Inc.) were used to simulate the sediment loads from potential sources in impaired and reference watersheds. The watershed model used in this study was the Generalized Watershed Loading Functions (GWLF) model (Haith and Shoemaker 1987). GWLF modeling was accomplished using the BasinSim 1.0 watershed simulation program, which is a windows-based modeling system that facilitates the development of model input data and provides additional functionality (Dai et al. 2000). Numeric endpoints were based on the unit-area loading rates that were calculated for the reference watershed. TMDLs were then developed for each impaired stream segment based on these endpoints and the results from load allocation scenarios.

5.2 Watershed Model

TMDLs were developed using BasinSim 1.0 (GWLF model) and the Tetra Tech Stream Module (discussed below). The GWLF model, which was originally developed by Cornell University (Haith and Shoemaker 1987, Haith et al. 1992), provides the ability to simulate runoff, sediment, and nutrient loadings from watersheds given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. GWLF is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on daily water balance totals that are summed to give monthly values.

GWLF is an aggregate distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogenous with respect to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for subsurface flow contributions. Daily water balances are computed for an unsaturated zone as well as for a saturated subsurface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

In order to consider the spatial distribution of sources in the TMDL development, the Ash Camp Creek watershed was divided into six subbasins (Figure 5.1). The flow and pollutant loadings from each subwatershed are routed through the stream networks using a stream routing and transport module developed by Tetra Tech. The transport module also has the capability of assessing streambank erosion. GWLF is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. The GWLF simulation results, including flow and sediment load, for each subwatershed are used to drive the stream flow routing, sediment transport, as well as streambank erosion simulation. As the routing and streambank erosion simulation uses hourly or smaller time step, the daily GWLF flow was extrapolated to a triangular hydrograph at an hourly increment by using the extended TR-55 procedures.

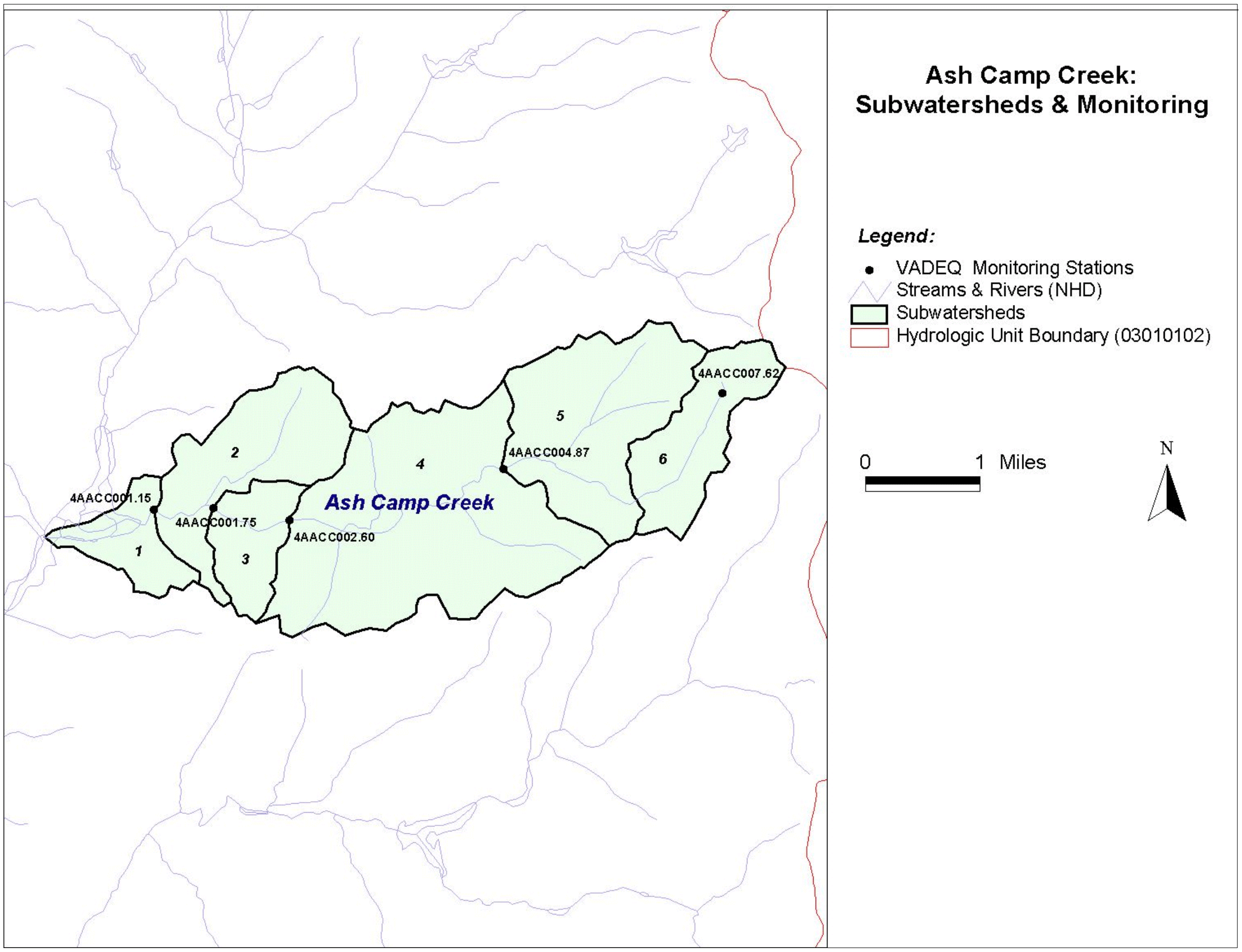

Figure 5.1 Ash Camp Creek subwatersheds

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss/erosion (K), the length/slope factor (LS), the vegetation cover factor (C), and the conservation practices factor (P). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Point source discharges also can contribute to loads to the stream. Evapotranspiration is determined using daily weather data and a cover factor dependent on land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values. All of the equations used by the model can be found in the original GWLF paper (Haith and Shoemaker 1987) and GWLF User's Manual (Haith et al. 1992).

For execution, the model requires three separate input files containing transport, nutrient, and weather-related data. The transport file (TRANSPRT.DAT) defines the necessary parameters for each source area to be considered (e.g., area size, curve number) as well as global parameters (e.g., initial storage, sediment delivery ratio) that apply to all source areas. The nutrient file (NUTRIENT.DAT) specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations). The nutrient file is necessary for the model to run but is not used in any of the calculations. The weather file (WEATHER.DAT) contains daily average temperature and total precipitation values for each year simulated.

Streambank Erosion Simulation Module

The streambank erosion simulation module employed the algorithm used in the Annualized Agricultural Nonpoint Source Model (AnnAGNPS) model (Theurer and Bingner, 2000). Sediment transport/routing and streambank erosion simulation were performed using three particle size classes (clay, silt, and sand), and the simulation time-step is one hour. For each subwatershed channel segment, the incoming sediment load is the total of local sources plus the loading from upstream subwatersheds. If the incoming sediment was greater than the sediment transport capacity specific to the physical features and the magnitude of flow of that segment, then the sediment deposition algorithm was used. If the incoming sediment is less than or equal to the sediment transport capacity, the sediment discharge at the outlet of the segment will be calculated as a function of the sediment transport capacity as well as the sediment availability factor for an erodible channel. Since the sediment transport capacity is specific to the magnitude of flow, the capacity for each particle size was calculated for each increment of the streamflow hydrograph. The erodibility of a channel was reflected by the sediment availability factor for the three particle sizes. These factors were assigned based on site-specific information regarding bank stability and vegetation cover conditions, and were further calibrated where monitoring data were available.

5.3 Model Setup

Watershed data needed to run the GWLF model in BasinSim 1.0 were generated using GIS spatial coverages, water quality monitoring and streamflow data, local weather data, literature values, and other information. Watershed boundaries for Ash Camp Creek and the reference watershed were delineated based on hydrologic and topographic data (USGS 7.5 minute digital topographic maps (24K DRG - Digital Raster Graphics)), and the location of DEQ monitoring stations. The outlet of the Ash Camp Creek watershed is the downstream limit of the impaired segment, which is also the mouth. The reference watershed outlet is located at the VADEQ biomonitoring station on Twittys Creek. To equate target and reference watershed areas for TMDL development, the total area for the reference watershed was reduced to be equal to the area of each Ash Camp Creek subwatershed, after hydrology calibration. To accomplish this, land use areas (in the reference watershed) were proportionally reduced based on the percent land use distribution.

Local rainfall and temperature data were used to simulate flow conditions in modeled watersheds. Daily precipitation and temperature data were obtained from local National Climatic Data Center (NCDC) weather stations. The weather station that corresponds with the modeled watersheds is shown in Table 5.1. The period of record selected for model calibration runs (January 1, 1991 through July 31, 1998 for the Twittys Creek and Ash Camp Creek watershed models) was based on the availability of recent weather data and corresponding streamflow records. Although the USGS flow data ends on 9/30/2002, it was observed that the data starting from August 1998 was much lower than normal flow. Therefore, the data recorded after August 1998 were not used in calibration. The weather data collected at the NCDC station of Camp Pickett (precipitation and temperature data) were used to construct the weather file used in both watershed simulations.

Table 5.1 Weather stations used in GWLF models

Modeled Watershed	Weather Station	Data Type	Data Period
Twittys Creek, Ash Camp Creek	Camp Pickett	Daily Precipitation, Daily Temperature	4/1/80 - 9/30/02

Daily streamflow data are needed to calibrate watershed hydrologic parameters in the GWLF model. A USGS gage station located on the North Meherrin River was used to calibrate both the reference watershed and the impaired watershed. Table 5.2 lists the USGS gaging station along with the period of record used for the watersheds.

Table 5.2 USGS gaging station used in modeling studies

Modeled Watershed	USGS station number	USGS gage location	Data Period
Twittys Creek, Ash Camp Creek	02051000	North Meherrin River near Lunenburg, VA	1/1/1991 to 7/31/1998

5.4 Explanation of Important Model Parameters

In the GWLF model, the nonpoint source load calculation is affected by terrain conditions, such as the amount of agricultural land, land slope, soil erodibility, farming practices used in the area, and by background concentrations of nutrients (nitrogen and phosphorus) in soil and groundwater. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized as follows:

Areal extent of different land use/cover categories: The MRLC land use coverage was used to calculate the area of each land use category in impaired and reference watersheds, respectively.

Curve number: This parameter determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type and is calculated directly using digital land use and soils coverages. Soils data for both the impaired and reference watersheds were obtained from the State Soil Geographic (STATSGO) database for Virginia, developed by NRCS.

K factor: This factor relates to inherent soil erodibility, and it affects the amount of soil erosion taking place on a given unit of land. The K factor and other Universal Soils Loss Equation (USLE) parameters were downloaded from the NRCS Natural Resources Inventory (NRI) database (1992). Average values for specific crops/land uses in Charlotte County were used. The predominant crop grown in these watersheds is corn; therefore, cropland values were based on data collected in corn crops.

LS factor: This factor signifies the steepness and length of slopes in an area and directly affects the amount of soil erosion.

C factor: This factor is related to the amount of vegetative cover in an area. In agricultural areas, this factor is largely controlled by the crops grown and the cultivation practices used. Values range from 0 to 1.0, with larger values indicating a higher potential for erosion.

P factor: This factor is directly related to the conservation practices used in agricultural areas. Values range from 0 to 1.0, with larger values indicating a lower potential for erosion.

Sediment delivery ratio: This parameter specifies the percentage of eroded sediment delivered to surface water and is empirically based on watershed size.

Unsaturated available water-holding capacity: This parameter relates to the amount of water that can be stored in the soil and affects runoff and infiltration.

Other less important factors that can affect sediment loads in a watershed also are included in the model. More detailed information about these parameters and those outlined above can be obtained from the GWLF User's Manual (Haith et al. 1992). Pages 15 through 41 of the manual provide specific details that describe equations and typical parameter values used in the model.

5.5 Hydrology Calibration

Using the input files created in the BasinSim 1.0, GWLF predicted overall water balances in impaired and reference watersheds. As discussed in Section 5.3, the modeling period is determined based on the availability of weather and flow data that were collected during the same time period. For the impaired watershed (Ash Camp Creek) weather data obtained from the NCDC meteorological station located at Camp Pickett were used to model the watersheds. However, the calibration period was governed by the availability of the USGS gaging data. Both the Ash Camp Creek watershed and the Twittys Creek watershed (reference watershed) were calibrated for a period of seven and a half years from 1/1991 to 7/1998 using the streamflow gage data from the nearby USGS gage 02051000 on the North Meherrin River. Although flow data at this gage were available up until 9/30/2002, the weather and flow data did not appear to match beginning in 1998. It was observed that the data starting from August 1998 was much lower than normal flow. Therefore, the data recorded after August 1998 were not used in calibration. Although the streamflow gage is in close proximity to the reference and the impaired streams, the gage did not coincide with the pour point of the watersheds. Hence, the streamflow measurements were normalized by area to facilitate calibration. Calibration statistics are presented in Table 5.3. These results indicate a good correlation between simulated and observed results for these watersheds. A total flow volume error percentage of less than five percent was achieved in calibration of the model for each watershed. In general the seasonal trends and peaks are captured reasonably well for the seven year period in the reference and impaired watersheds. Hydrology calibration results and the modeled time period for the reference and the impaired watersheds are given in Figures 5.2 and 5.3. Differences between observed and modeled flows in these watersheds are likely due to inherent errors in flow estimation procedures based on normalization for watershed size and possibly due to the proximity of the location of the weather station to the watersheds and the flow gage.

Table 5.3 GWLF flow calibration statistics

Modeled Watershed	Simulation Period	R2 (Correlation) Value	Total Volume % Error
Twittys Creek	1/1/91 - 7/31/98	0.6154	1%
Ash Camp Creek	1/1/91 - 7/31/98	0.6393	4%

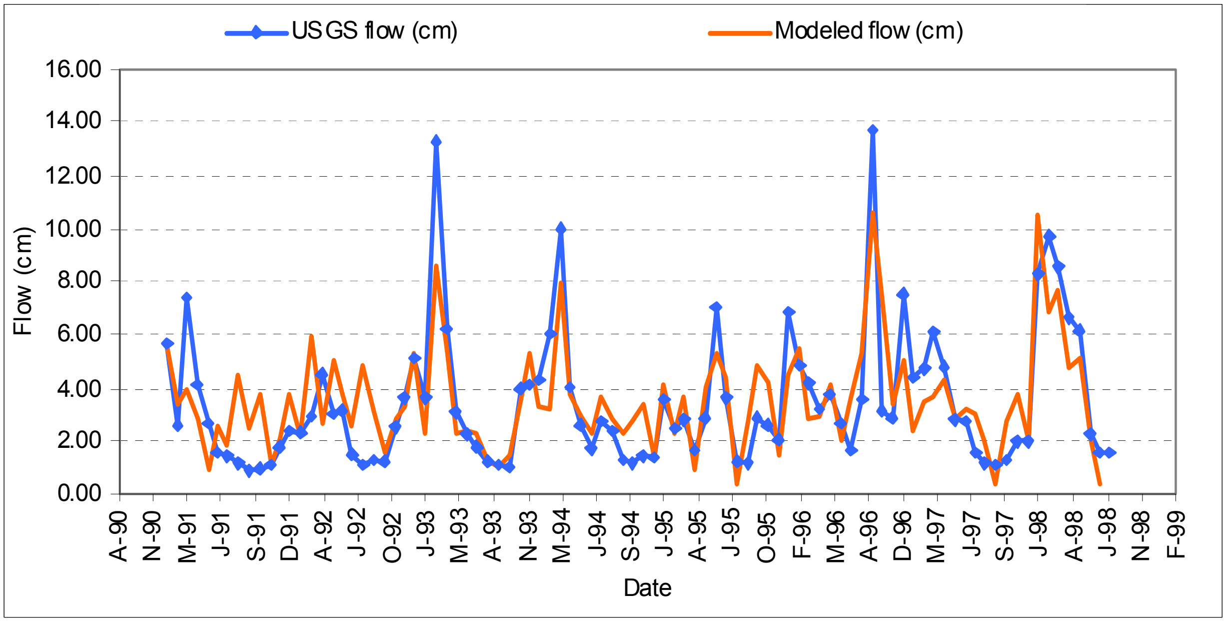

Figure 5.2 Hydrology calibration - Twittys Creek at modeled watershed outlet (USGS gage 02051000, 1/1/91 - 7/31/98)

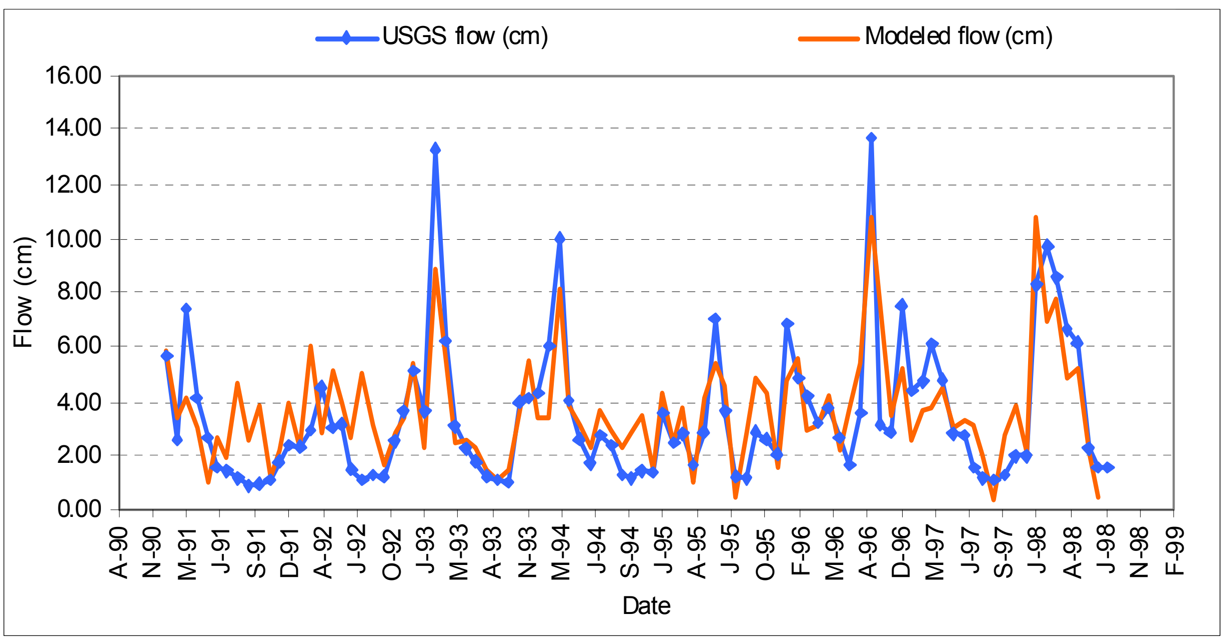

Figure 5.3 Hydrology calibration - Ash Camp Creek at modeled watershed outlet (USGS 02051000, 1/1/91 - 7/31/98)

SECTION 6

TMDL METHODOLOGY

6.1 TMDL Calculation

Impaired and reference watershed models were calibrated for hydrology using different modeling periods and weather input files. To establish baseline (reference watershed) loadings for sediment the GWLF model for Twittys Creek was used. For TMDL calculation both the calibrated reference and impaired watershed were run for a 11-year period from 4/1/1991 to 3/31/2002. This was done to standardize the modeling period. Based on the weather and limited flow data it is assumed that this period sufficiently captures hydrologic and weather conditions. In addition, the total area for the reference watershed was reduced to be equal to each target subwatershed, as discussed in Section 5.3. This was necessary because watershed size influences sediment delivery to the stream and other model variables.

The 11-year means for pollutants of concern were determined for each land use/source category in the reference and the impaired watershed. The first few months of the model run were excluded from the pollutant load summaries because the GWLF model takes a few months in the first year to stabilize. Model output is only presented for the years following the initialization year, although the model was run for an eleven year time period.

The existing and allocated average annual sediment loads and percent reductions for the Ash Camp Creek watershed are presented in Table 6.1. The loads in this table are sums of the loads from each subbasin by source within that watershed; the total is a sum of loads from all sources. More detailed allocation tables with the loads and percent reductions for each individual subbasin are presented in Appendix A.

The sediment loads contributed by point sources in the Ash Camp Creek watershed were added to the most adjacent stream segment, and routed downstream on a daily basis. Point source loads are presented in the tables as a source category.

Table 6.1 Overall average annual sediment loads and recommended allocations for Ash Camp Creek

Source Category	*Existing Loads*		*Allocated Loads (TMDL minus 10 % MOS)*		
	Sediment Load (ton/yr) *	Sediment % of Total	Sediment Load Allocation (ton/yr) *	Sediment % of Total	Sediment % Reduction
Pasture/Hay	261.0	44.0%	120.5	46.3%	53.8%
Row Crop	195.3	32.9%	72.5	27.8%	62.9%
Transitional	111.5	18.8%	41.8	16.1%	62.5%
Deciduous Forest	2.5	0.4%	2.5	0.9%	0.0%
Evergreen Forest	1.0	0.2%	1.0	0.4%	0.0%
Mixed Forest	1.4	0.2%	1.4	0.5%	0.0%
Urban	0.0	0.0%	0.0	0.0%	0.0%
Groundwater	0.0	0.0%	0.0	0.0%	0.0%
PointSource	20.7	3.5%	20.7	8.0%	0.0%
Total	**593.4**		**260.3**		**56.1%**

* Overall loads for sources were calculated by summing the loads from each source in each watershed.

The sediment loads contributed by urban areas were minimal in comparison to loads from other sources. The output from the model shows no sediment loadings from urban sources because the loads were so minute that numeric values were truncated within the model, resulting in loads of zero tons per year. Although loads are actually being contributed by urban lands, due to the insignificance in size of the loads and the limitation of the model to represent such small loads, the table shows no loads from urban areas.

Loads for bank erosion and channel deposition are not shown in the tables, however the overall loads account for such stream processes. Allocations to each subbasin for each stream segment (channel) were done while taking into account the amount of sediment gained or lost in each stream channel due to erosion or deposition. When deposition occurs, sediment is subtracted from the load that is carried to downstream channels; when erosion occurs, the sediment load to downstream channels is increased. The actual net erosion/deposition in each channel is shown in a more detailed allocation table in Appendix A.

The TMDLs established for Ash Camp Creek consist of a point source wasteload allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). The sediment TMDL for Ash Camp Creek was based on the total load calculated for the reference watershed Twittys Creek (area adjusted to the appropriate watershed size).

The TMDL equation is as follows:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis. An explicit MOS of ten percent was used in TMDL calculations to provide an additional level of protection for designated uses.

The TMDL for Ash Camp Creek (entire watershed) was calculated by adding reference watershed loads for sediment together with point source loads to give the TMDL value (Table 6.2).

Table 6.2 Sediment TMDL for Ash Camp Creek

Stream	Pollutant	TMDL (tons/yr)	LA (tons/yr)	WLA (tons/yr)	MOS (10%) (tons/yr)	Overall % Reduction
Ash Camp Creek	Sediment	289.2	239.6	20.7 (*Keysville STP = 20.7*)	28.9	56.1%

6.2 Waste Load Allocation

A wasteload allocation was assigned to the point source facility in the watershed. The point source was represented using the new (upgraded) permit conditions and no reductions were required from the point source in the TMDLs. Permit requirements are expected to result in attainment of WLAs as required by the TMDL.

6.3 Load Allocation

Load allocations were assigned to each source category in the watersheds. The recommended scenario for Ash Camp Creek (Tables 6.1) is based on maintaining the existing percent load contribution from each source category. Table 6.2 presents the estimated results from the model for the entire Ash Camp Creek watershed. The recommended scenarios balance the reductions from agricultural and urban sources by maintaining existing watershed loading characteristics. The loadings from source categories were allocated according to their existing loads distribution. For instance, sediment loads from forest lands represent the natural condition that would be expected to exist; therefore, the loading from forest lands was not reduced.

Figure 6.1 shows the recommended sediment percent reduction for each subwatershed.

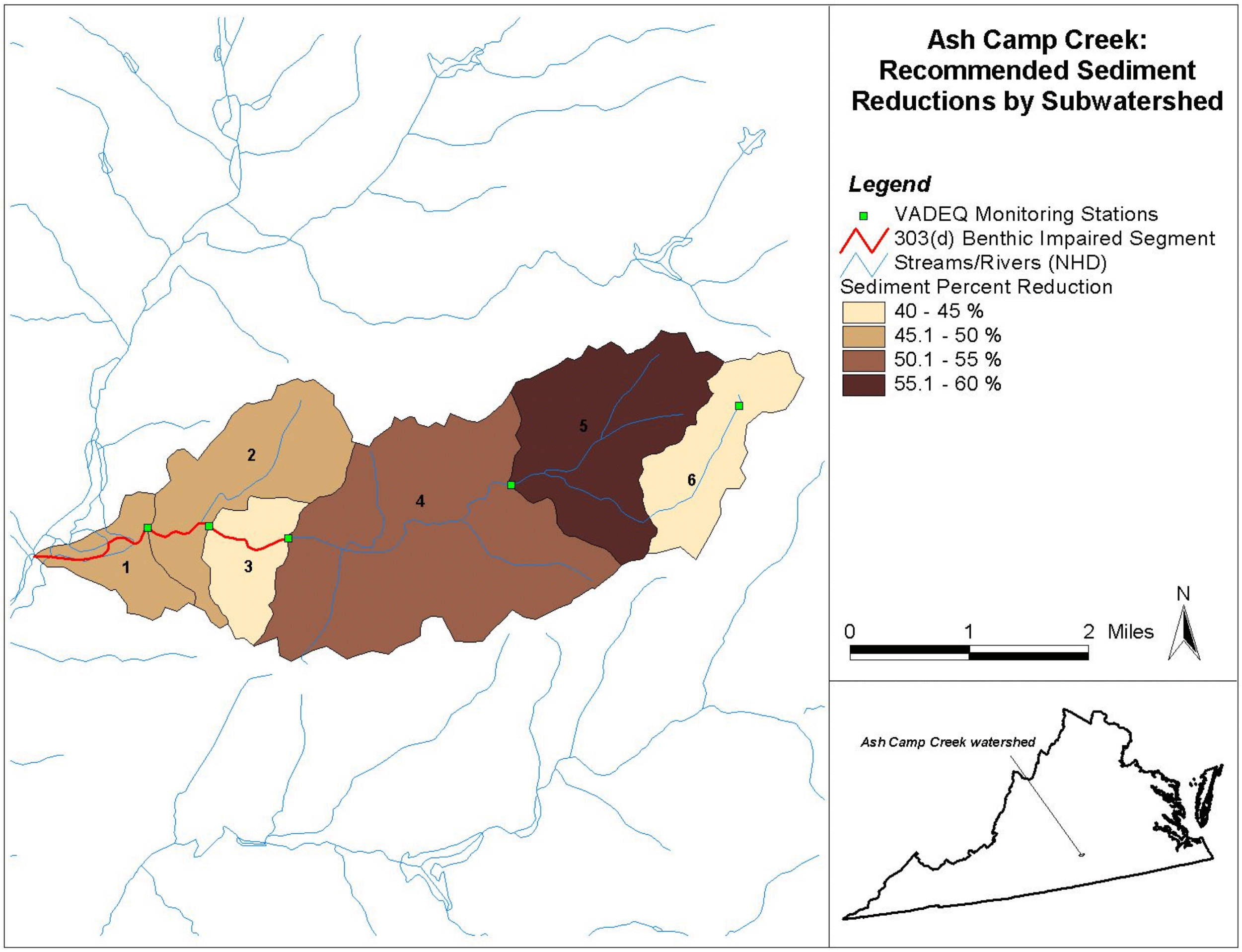

Figure 6.1 Recommended sediment percent reductions for Ash Camp Creek

6.4 Consideration of Critical Conditions

The GWLF model is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is usually a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing this TMDL using average annual conditions is protective of the waterbody.

6.5 Consideration of Seasonal Variations

The continuous-simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The combination of these model features accounts for seasonal variability.

SECTION 7

REASONABLE ASSURANCE AND IMPLEMENTATION

7.1 Reasonable Assurance

Sediment reductions in the TMDLs are allocated according to the source loading characteristics for each watershed. Implementation of best management practices (BMPs) in the affected areas should achieve the loading reduction goals established in the TMDLs. Substantial reductions in the amount of sediment reaching the streams can be made through the planting of riparian buffer zones, contour strips, and cover crops. These BMPs range in efficiency from 20 percent to 70 percent for sediment reduction. Other possibilities for attaining the desired reductions in sediment include stabilization of stream banks and stream fencing. Further "ground truthing" will be performed in order to assess existing BMPs, and to determine the most cost-effective and environmentally protective combination of future BMPs required for meeting the sediment reductions outlined in this report.

7.2 Follow-Up Monitoring

The Department of Environmental Quality will maintain the existing monitoring stations in these watersheds in accordance with its ambient monitoring program. VADEQ and VADCR will continue to use data from these monitoring stations to evaluate improvements in the benthic communities and the effectiveness of the TMDL in attaining and maintaining water quality standards.

7.3 Regulatory Framework

This TMDL is the first step toward the expeditious attainment of water quality standards. The second step will be to develop a TMDL implementation plan, and the final step is to implement the TMDL until water quality standards are attained.

Section 303(d) of the Clean Water Act (CWA) and current EPA regulations do not require the development of implementation strategies. However, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (WQMIRA) directs VADEQ in section 62.1-44.19.7 to "develop and implement a plan to achieve fully supporting status for impaired waters". The Act also establishes that the implementation plan shall include that date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated cost, benefits and environmental impact of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process". The listed elements include implementation actions/management measures, time line, legal or regulatory controls, time required to attain water quality standards, monitoring plan and milestones for attaining water quality standards. Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of VADEQ, VADCR and other cooperating agencies.

Once developed, VADEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan, in accordance with the CWA's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and VADEQ, VADEQ also submitted a draft Continuous Planning Process to EPA in which VADEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

7.4 Implementation Funding Sources

One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. In response to the federal Clean Water Action Plan, Virginia developed a Unified Watershed Assessment that identifies watershed priorities. Watershed restoration activities, such as TMDL implementation, within these priority watersheds are eligible for Section 319 funding. Increases in Section 319 funding in future years will be targeted towards TMDL implementation and watershed restoration. Other funding sources for implementation include the USDA's CREP program, the state revolving loan program, and the VA Water Quality Improvement Fund.

7.5 TMDL Implementation

Implementation of best management practices (BMPs) in the watersheds will occur in stages. The benefit of staged implementation is that it provides a mechanism for developing public support and for evaluating the adequacy of the TMDL in achieving the water quality standard. Implementation of these TMDL will also contribute to on-going water quality improvement efforts in these watersheds.

7.6 Water Quality Standards

If implementation of reasonable BMPs has failed to improve or restore the benthic community and additional controls would have widespread social and economic impacts, VADEQ has the option of performing a Use Attainability Analysis (UAA) using the factors set forth in 40 CFR ' 131.10(g). A UAA is a structured scientific assessment of the factors affecting the attainment of the use, which may include physical, chemical, biological, and economic factors as described in the Federal Regulations. The primary factors to include are as follows: 1. the factor of widespread social and economic impacts 2. human caused conditions and sources of pollution prevent the attainment of the use and cannot be remedied. The stakeholders in the watershed, Virginia, and EPA will have an opportunity to comment on these special studies.

SECTION 8

PUBLIC PARTICIPATION

A stakeholder and TMDL study kickoff meeting was held on April 1, 2003. A site visit to Ash Camp Creek and Twittys Creek was also conducted on this date. Important information regarding likely stressors and sources was discussed with state environmental personnel and local stakeholders.

The first public meeting on the development of TMDLs for Ash Camp Creek was held on October 15, 2003 from 7-10 p.m. at the Charlotte County Administration Building in Charlotte Court House, Virginia. Copies of the presentation materials were made available for public distribution at the meeting. No written comments were received.

The second public meeting on the TMDL development for Ash Camp Creek was held on December 2, 2003 from 7-10 p.m. at the Charlotte County Administration Building in Charlotte Court House, Virginia. Copies of the Draft TMDL report and presentation materials were made available for public distribution at the meeting. No written comments were received.

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